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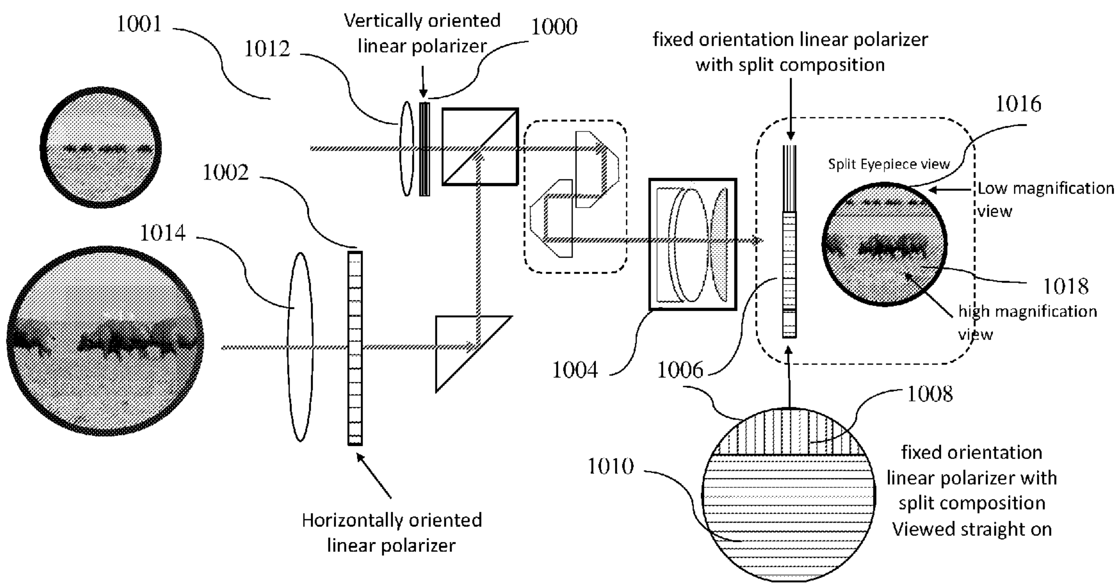

Figure 10

(57) **Abstract:** Viewing apparati and methods. In one example, the viewing apparatus comprises a first objective lens having a first focal length; a second objective lens having a second focal length; and a common eyepiece lens having a third focal length; wherein the viewing apparatus is configured, in a first viewing mode, that such an image viewable through the common eyepiece lens comprises, in different parts thereof, respective portions of respective fields of view, FOV, through the first objective lens and through the second objective lens with different magnifications.

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DEVICE AND METHOD TO PROVIDE DIFFERENT OPTICAL MAGNIFICATIONS

FIELD OF INVENTION

The present invention relates broadly to a viewing apparatus and method, in particular to a device and method to provide different optical magnifications of the same region of interest.

BACKGROUND

Any mention and/or discussion of prior art throughout the specification should not be considered, in any way, as an admission that this prior art is well known or forms part of common general knowledge in the field.

In optically magnifying instruments, such as monoculars, binoculars, spotter scopes or telescopic sights, it is typically cumbersome to switch between different fields of view. Such switching can, however, be helpful, for example using binoculars at lower magnification to track a moving object, and to switch to higher magnification for identification, such as during bird watching.

Embodiments of the present invention seek to address at least one of the above problems.

SUMMARY

In accordance with a first aspect of the present invention, there is provided a viewing apparatus comprising:

a first objective lens having a first focal length;

a second objective lens having a second focal length; and

a common eyepiece lens having a third focal length or first and second eyepiece lenses having fourth and fifth focal lengths, respectively;

wherein the viewing apparatus is configured, in a first viewing mode, that such:

an image viewable through the common eyepiece lens comprises, in different parts thereof, respective portions of respective fields of view, FOV, through the first objective lens and through the second objective lens with different magnifications, or

a combined image viewable through the first and second eyepiece lenses simultaneously comprises, in different parts thereof, respective portions of respective fields of view, FOV, through the first objective lens and through the second objective lens with different magnifications.

In accordance with a second aspect of the present invention, there is provided a viewing apparatus comprising:

a first objective lens having a first focal length;

a second objective lens having a second focal length;

a common eyepiece lens having a third focal length;

a combiner element for combining respective optical paths through the first and second objective lenses into a common optical paths towards the common eyepiece lens;

first and second polarizer elements disposed in the first and second optical paths, respectively, and having different polarization orientations; and

a liquid crystal element and a third polarizer element disposed in the common optical path;

wherein the viewing apparatus is configured that such:

depending on a polarization alternating state of the liquid crystal, an image viewable through the common eyepiece lens selectively comprises a field of view, FOV, through the first objective lens or through the second objective lens with different magnifications.

In accordance with a third aspect of the present invention, there is provided a method of providing different fields of view via one or more eyepieces, the method comprising the steps of:

providing a first objective lens having a first focal length;

providing a second objective lens having a second focal length; and

providing a common eyepiece lens having a third focal length or providing first and second eyepiece lenses having fourth and fifth focal lengths, respectively;

and providing, in a first viewing mode:

a first image viewable through the common eyepiece lens which comprises, in different parts thereof, respective portions of respective fields of view, FOV, through the first objective lens and through the second objective lens with different magnifications, or

a combined image viewable through the first and second eyepiece lenses simultaneously which comprises, in different parts thereof, respective portions of respective fields of view, FOV, through the first objective lens and through the second objective lens with different magnifications.

In accordance with a fourth aspect of the present invention, there is provided a method of providing a view via an eyepiece, the method comprising the steps of:

providing a first objective lens having a first focal length;

providing a second objective lens having a second focal length;

providing a common eyepiece lens having a third focal length;

providing a combiner element for combining respective optical paths through the first and second objective lenses into a common optical paths towards the common eyepiece lens;

providing first and second polarizer elements disposed in the first and second optical paths, respectively, and having different polarization orientations;

providing a liquid crystal element and a third polarizer element disposed in the common optical path; and

depending on an polarization alternating state of the liquid crystal, providing an image viewable through the common eyepiece lens which selectively comprises a field of view, FOV, through the first objective lens or through the second objective lens with different magnifications.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example only, and in conjunction with the drawings, in which:

Figure 1 shows a schematic drawing illustrating operation of a refractive telescope.

Figure 2(a) shows a schematic cross-sectional drawings of a scope.

Figure 2(b) shows a schematic drawing illustrating operation of a scope.

Figure 3(a) shows a schematic drawing of a Schmidt–Pechan prism.

Figure 3(b) shows a schematic drawing of a Porro prism.

Figure 4(a) shows a schematic drawing illustrating binoculars with Schmidt–Pechan prisms.

Figure 4(b) shows a schematic drawing illustrating binoculars with Porro prisms.

Figure 5(a) shows a high magnification view of a scene.

Figure 5(b) shows a low magnification view of the scene.

Figure 6 shows a schematic drawing illustrating operation of a viewing apparatus according to an example embodiment.

Figure 7(a) shows a schematic drawing illustrating operation of a viewing apparatus according to an example embodiment.

Figure 7(b) shows a schematic drawing illustrating operation of a viewing apparatus according to an example embodiment.

Figure 8(a) shows a schematic drawing illustrating operation of a scope.

Figure 8(b) shows a schematic drawing illustrating operation of a viewing apparatus according to an example embodiment.

Figure 9(a) shows a schematic drawing illustrating operation of a viewing apparatus according to an example embodiment.

Figure 9(b) shows a schematic drawing illustrating operation of a viewing apparatus according to an example embodiment.

Figure 10 shows a schematic drawing illustrating operation of a viewing apparatus according to an example embodiment.

Figure 11(a) shows a schematic drawing illustrating operation of a viewing apparatus according to an example embodiment.

Figure 11(b) shows a schematic drawing illustrating operation of a viewing apparatus according to an example embodiment.

Figure 12 shows a schematic drawing illustrating operation of a viewing apparatus according to an example embodiment.

Figure 13 shows a schematic drawing of a custom prism design for use in an example embodiment.

Figure 14 shows a schematic drawing of a custom prism design for use in an example embodiment.

Figure 15 shows a flowchart illustrating a method of providing different fields of view via one or more eyepieces, according to an example embodiment.

Figure 16 shows a flowchart illustrating a method of providing a view via an eyepiece, according to an example embodiment.

DETAILED DESCRIPTION

In embodiments of the present invention described herein, two orthogonal entrance pathways into a cube beam splitter (CBS) are used to provide two different magnification views of the same direction. That is, the same direction of view but with different field of view are provided. One non-limiting example application for embodiments of the present invention is to modify optically magnifying instruments, such as monoculars, binoculars, spotter scopes or telescopic sights, so as to be capable of rapidly switching between different fields of view, or to observe both fields of view simultaneously. This can be helpful, for example when high magnification detail viewing as well as tracking anything moving outside the narrow high magnification view are desired, such as for viewing birds. Having the option to rapidly switch to, or simultaneously observe a wider field of view, preferably without making any mechanical adjustments according to an example embodiment is a big help, allowing interesting objects outside the narrow view to be rapidly located and centred, for viewing at high magnification without having to randomly move around the instrument.

In an example embodiment, two objective lenses with differing focal lengths (and diameters) are used to focus light along each pathway into the CBS, which allows selection of light from a single pathway to exit the CBS. The selected light then passes through an image erecting element and an eyepiece lens. Thus the same region of interest can be viewed at different magnifications by switching the open/closed state of shutters attached to the CBS, according to an example embodiment, thereby changing which objective lens illuminates the eyepiece. This allows the region of interest to be easily located at low magnification and then viewed at higher magnification.

In another example embodiment of the present invention, no shutters are used to allow/block light from one or the other objective through to the eyepiece. Instead, a reduction in the angular or spatial cone of light transmitted through each objective is used to selectively allow which portions of each view are transmitted to the eyepiece, allowing a split view in the eyepiece comprising, for example, a high magnification view in the lower two thirds of the eyepiece view, and a low magnification view of the same DOV in the upper one third of the eyepiece view. Now, one may view distant objects at high magnification while simultaneously viewing a wider field of view to better identify any object of interest outside the high magnification FOV. In some instances additional optical elements may be located in front of one of the objective lenses to vertically offset the two DOV by a few degrees.

It is noted that embodiments of the present invention can also be applied by modifying any terrestrial form of a refracting telescope, including monoculars, binoculars, spotter scopes or telescopic sights. If modification of one form of a refracting telescope is used to highlight an example embodiment of this invention then it is understood that the invention applies to modification of any of these forms in different embodiments.

Figure 1 shows the major items of a refracting telescope 100, comprising just two lenses: a large objective lens 102 to gather and focus light from the distant object 104 of interest onto an eyepiece lens 106, which magnifies the image 108 and transmits it to the eye. Optical magnification is defined as the size of the image 108 as viewed through the telescope eyepiece compared with the same object 104 viewed by the naked eye. For a refracting telescope 100 the magnification is equal to the focal length of the objective lens 102, f_o, divided by the focal length of the eyepiece lens 106, f_e, i.e. f_o / f_e. Achieving a high magnification thus involves using an objective with a long focal length, also resulting in a longer optical path length and so a longer instrument.

In figure 1 the viewed image 108 is inverted by the focusing action of the objective lens 102. While this is generally acceptable for astronomical observations, all terrestrial versions of this instrument, such as binoculars, monoculars, telescopic sights, spotter scopes, etc typically use an additional optical element to provide a second image inversion stage, thus allowing the viewer to see the same image orientation as that viewed with the naked eye. There are two classes of such inverting optical elements – image erecting lenses and different forms of image erecting prisms.

A telescopic sight 200, commonly called a scope, is an optical sighting and magnifying instrument which uses one or two additional lenses (indicated at numeral 202) between the objective lens 204 and the eyepiece 206 to erect the image to the correct viewing orientation, see figure 2a and b. A feature of such a system 200 is its long path length; this is acceptable for a telescopic sight as it naturally conforms to the long rifle barrel, which is a typical application of scopes, and the in-line optics allow a narrow profile.

A monocular is a modified refracting telescope used to magnify the images of distant terrestrial objects, by additionally passing light through prisms to erect the image in the eyepiece, resulting in a lightweight, compact telescope. Binoculars, (also called field glasses) are essentially just two monoculars mounted side-by-side and aligned to point in the same direction, allowing the viewer to use both eyes when viewing distant objects. Unlike a monocular, binoculars give users a three-dimensional (3D) image: for nearer objects the two views, presented to each of the viewer's eyes from slightly different viewpoints, produce a merged view with an impression of depth.

The use of erecting lenses for all terrestrial versions of the refracting telescope, including binoculars and monoculars has a serious disadvantage in that it would be excessively long. Because of this, the most commonly-used form of optical element in all such instruments to provide a second image inversion is a combination of prisms. Both involve folding of the optical path length (see figure 3), allowing image inversion in a short physical length. As can be seen in figure 3a, the path length of light through a Schmidt–Pechan prism 300 (commonly referred to as a Roof prism) involves multiple reflections through the combined geometry. Schmidt–Pechan prism designs create a magnifying instrument that is narrow and compact, with objective lenses that are in-line with the eyepieces, see for example the binoculars 400 in figure 4a. A Porro prism design comprises a pair of two right angle prisms 310, 312, each of which deflects light through 180°, as shown in figure 3b. The combined effect of the Z-shaped optical deflection is to invert the image. This results in binoculars 410 that are wide, with objective lenses that are well separated and offset from the eyepieces, see figure 4b.

As with all variations of the refracting telescope including monoculars and binoculars, FOV and magnification are inversely related – as the magnification increase the FOV decreases, and vice versa. Figure 5 shows an example of what might be viewed in monoculars and binoculars at low and high magnification. For 4× magnification the FOV 500 is about 220m at a distance of 1000m (see figure 5b), whereas for a 10× magnification the FOV 502 is at about 115m (see figure 5a). For monoculars and binoculars the most commonly-used magnification is 8× or 10×, providing a usable magnification where the instrument is reasonably easy to hold steady by hand. At these magnifications, the FOV is relatively wide, making it easier to locate and follow distant objects. Optical performance is usually defined by just two numbers:

magnification and objective lens diameter: for example, numbers of 8×30 mean the magnification is 8 and the objective lens diameter is 30mm.

In Figure 4a an internal focus lens 402 after the objective lens 404 is shown; this can be moved along the optical path to change the focus in order to see objects at different distances. It is noteworthy that there are “focus free” binoculars which require no such internal focus lens; such binoculars are meant to focus only on distant objects where any differences in focal length are minimal. It is further worth noting that “zoom” monoculars and binoculars allow a change in magnification and hence FOV by adjusting the position/focal length of the eyepiece. While they sound ideal, in practice they are not widely used for two reasons: (i) it is difficult and slow to change the eyepiece focal length / magnification, as this requires manually rotating a lever to the side of the eyepiece and possible refocusing, and (ii) the field of view is considerably smaller than for a similar optical magnification in a standard non-zoom design.

Embodiments of the present Invention

As one would expect, the level of detail is much better at high magnification, see figure 5, but the field of view is smaller. For stationary objects, a user typically first identifies the region of interest with the naked eye and then views this direction through high magnification binoculars aimed in the direction of interest, with trial and error involved in finding the optimal region. If, however, the objects are moving or one is not sure what one wants to look at, it would be better to have the additional option of a lower magnification view so that one could locate the initial object of interest, or relocate it if it rapidly moves/flies out of the narrow FOV.

Use of optical shutters according to example embodiments

Figure 6 shows an example embodiment of an viewing apparatus 600, based on a Schmidt–Pechan prism 602 and eyepiece 604 which are both located in line with a low magnification (small diameter, typically 25mm) objective lens 606 with a typical focal length of 100mm. Light focused by the low magnification objective lens 606 enters a cube beam splitter (CBS) 608, which is equipped with optical shutters 610, 612 on two entrance surfaces. The action of the non-polarizing CBS 608 is such that it transmits to the Schmidt–Pechan prism 602 50% of light entering from the front direction and also reflects 50% of light entering from the side direction to the Schmidt–Pechan prism 602. When a particular shutter 610, 612 is open then light passes through it, and when it is closed all light is blocked. One shutter is open while the other is closed, and their open/closed state can be rapidly switched by means of a low applied voltage (less than 5 V), thereby allowing light from either optical channel to reach the eyepiece 604. With the front shutter 610 open (and side shutter 612 closed), only light from the low magnification objective 606 passes through the Schmidt–Pechan prism 602 where it is inverted, and a low magnification view is observed in the eyepiece 604 with the correct orientation.

A high magnification (large diameter, typically 50mm) objective lens 618 with a long focal length (of the order of 250mm) is located parallel to the low magnification objective lens 606, though protrudes further forward in keeping with its longer focal length. Light passing through the high magnification objective lens 618 is reflected through 90° by a right angle prism (or mirror) 620 and enters the CBS 608 when the side shutter 612 is open (i.e. when the front shutter 610 is closed). Light is again reflected by 90° to its original direction in the CBS 608. The image orientation remains the same as before the first 90° reflection; the light then passes through the Schmidt–Pechan prism 602 where it is inverted and then into the eyepiece 604, allowing the high magnification view to be viewed with the correct orientation. An additional benefit of this geometry is that the optical path length from the high magnification channel is extended by the distance between the two right angle mirrors/prisms, allowing a high magnification to be used without extending the instrument length.

In this example embodiment, one can select between two FOV provided by two objective lenses 606, 618 with focal lengths of 100 mm and 250 mm, respectively, providing a ratio of FOV and magnification of 2.5. The low magnification channel, by definition, is required to be short owing to the short focal length; it is thus not practical to consider the converse geometry where the 90° mirror is located in the low magnification channel as this would significantly extend its path length to the point where a short focal length objective could not be used.

Figure 7a shows another example embodiment 701 of the present invention which uses a Porro prism 700 instead of a Schmidt–Pechan prism. Now, the eyepiece 702 is not in-line with either of the objective lenses 704, 706 (as is the case for standard Porro prism binoculars and monoculars, compare figure 4b). Figure 7b shows a similar design 710 according to another example embodiments, but now the second 180° deflection stage of the Porro prism 712 is split into two 90° deflections, one at prism 714 and the other in the CBS 716, separated by an additional path length. In this geometry the eyepiece is in line with the larger objective lens 706, and the path length for the high magnification channel is extended by twice the separation between the two channels. This results in a high magnification achieved in a short distance separation between the larger objective lens 706 and eyepiece 702.

Figure 8b shows how an example embodiment of the present invention may be applied to a telescopic sight apparatus 800, which typically uses an image erecting lens 802 instead of a prism combination to provide the second inversion stage (compare figure 2). Figure 8a shows the geometry of a conventional telescopic sight 804, for comparison.

There are several geometries for incorporating the direction switching in different embodiments. Figure 8b shows one of them to highlight how the present invention can be used in telescopic sights. The major difference is that now there is no image erecting prism in the primary (high magnification) optical channel, which might be used to provide the second inversion stage for the secondary optical channel. Thus the secondary (low magnification) optical channel incorporates its own second inversion element. In the embodiment in figure 8b, this is a Schmidt–Pechan prism 810, located after the first 90° (downwards) deflection, i.e. disposed between the two optical channels. As in figures 6 and 7, there is a CBS 812 fitted with optical shutters 814, 816 in the primary optical channel which allows light from either objective 818, 820 to be transmitted to the eyepiece 822.

The above geometries in figures 6 to 8 utilize optical shutters before the cube beam splitter, so that light from a single objective lens illuminates the eyepiece at any one time. In the following, different embodiments are described for selecting between two views when both illuminate the eyepiece at the same time.

Use of linear polarizers according to example embodiments

It is noted that a Schmidt–Pechan prism without expensive phase-correcting coatings strongly affects the polarization of transmitted light, whereas a Porro prism largely does not do so. The following example embodiments thus preferably apply to the designs based on the use of a Porro prism.

In figure 9a, spatially uniform linear polarizers 900, 902 are inserted at some location along the beam trajectories before the CBS 904. In this example embodiment of a viewing apparatus 901, a vertically-oriented polarizer 900 is placed in the path of the low magnification (upper) objective lens 906 and a horizontally-oriented polarizer 902 is placed in the path of the high magnification (lower) objective lens 908. Both polarizers 900, 902 transmit approximately 50% of incident light, polarized orthogonally to each other. Another spatially uniform, but rotatable linear polarizer 910 is placed before or after the eyepiece 912. Rotating this polarizer 910 allows the viewer to switch between one or the other FOV 914, 916 from either of the objective lenses 906, 908. In figure 9a the rotation is manual. However, the same process can be performed much faster by placing a liquid crystal layer 918 before the polarizer 910, as shown in the modified example embodiment 920 in figure 9b. The liquid crystal layer's 918 function is to change the polarization of transmitted light by 90° when a small voltage (typically 5V) is applied. Now, at the switch of a button (not shown), one may electrically change the polarization of light incident on the uniform spatial filter 919, for example after the eyepiece 912, allowing rapid changes between the two FOV 914, 916.

The above embodiments describe methods of switching between different FOV in a viewing apparatus according to example embodiments so that a view of either low or high magnification is seen sequentially. Below are described example embodiments where portions of both FOVs are viewed simultaneously in one eyepiece.

Split views according to example embodiments

In the viewing apparatus 1001 according to an example embodiment shown in figure 10 each optical channel has a linear polarizer 1000, 1002 in its path, oriented at right angles to each other. Located after the eyepiece 1004 is a linear polarizer 1006, which comprises two separated regions 1008, 1010 of orthogonal orientation. Thus polarized light from both objective lenses 1012, 1014 is incident on the spatial linear polarizer filter 1006. In this example embodiment the upper portion1008 of the filter 1006 transmits only vertically polarized light and the lower portion 1010 transmits only horizontally polarized light. In this way, the viewer observes a split view in the eyepiece comprising portions 1016, 1018 of the low and high magnification views, respectively. The proportion of each view may simply be changed by moving the spatial filter 1006 e.g. upwards or downwards, e,g, using a spatial filter 1006 with the upper half transmitting only vertically polarized light and the lower half transmitting only horizontally polarized light. It is noted that while locating the linear polarizer 1006 after the eyepiece 1004 can provide for an easier set-up, in particular in terms of movability, the linear polarizer 1006 may be located before the eyepiece 1004 in another example embodiment.

Another example embodiment of a viewing apparatus 1101 for forming a split view in the eyepiece, comprising portions of the two different magnification views, is illustrated in figure 11a. In this example embodiment there are no polarizers or liquid crystal layers used to provide a combined view. Instead there is angular collimation, here using blocking elements 1100, 1102 at selected points along the optical path lengths, so that the view in the single eyepiece 1103 comprises portions 1104, 1106 of both FOV.

This allows a view of the same scene at different magnifications with a single eyepiece. With further refinement different scenes can similarly be viewed according to example embodiments. This may be done by combining the use of the angular collimation illustrated in figure 11a with, for example, wedge prism(s) 1120, which shift the field of view by a small angle of e.g. 2° - preferably small enough such that chromatic distortions of the wedge prism 1120 are not serious in degrading the viewed image, as shown in figure 11b. With reference to figure 6, another way that an angular offset between the FOV can be achieved according to another example embodiment is with a small tilt of the 90° prism (or mirror) 620 in the required plane of deflection. Thus, in addition to the 90° deflection shown in figure 6, the prism (or mirror) 620 also imparts a small angular deflection in the transverse plane according to another example embodiment, thereby allowing a slightly different angular cone of light to be transmitted into the cube beam splitter 608.

The above described example embodiments considered how to combine or switch between two fields of view as seen using a single eyepiece. However, it is noted that the above example embodiments can be equally applied by modifying any form of terrestrial telescope, including binoculars, monoculars and telescopic sights. For example, one advantage of a viewing apparatus in the form of modified binoculars (with two FOV for each eyepiece) can be that where the same one of two switchable views are seen in each eyepiece, higher light intensity and depth perception of a stereo view can be obtained, compared to the single eyepiece view in the embodiments described above.

Differing fields of view in two eyepieces of modified binoculars according to example embodiments

In normal operation of binoculars the optical parameters of the "right" and "left" eye views are the same, with identical objective lenses, eyepieces lenses and focal lengths, leading to the same view being seen through each eyepiece, with a small angular offset which may be useful for rendering the view as a 3D perspective. As mentioned above, in one example embodiment of the present invention, modified binoculars can be provided with two FOV for each eyepiece, where the same one of the two switchable views are seen in each eyepiece.

On the other hand, in the following it is described how the two separate eyepieces of binoculars may be used to observe different fields of view according to example embodiments, which may be switched or combined using methods described in the example embodiments above. Figure 12 shows two optical channels of a binoculars-based viewing apparatus 1201 according to an example embodiment, comprising two objective lenses 1200, 1202, each connected to separate eyepieces 1204, 1206. In the example embodiment shown in figure 12, the optical magnifications of the left and right views are different. In this case where the overall length of both optical channels remains the same, this is because the eyepieces' 1204, 1206 focal lengths are different, while the objective lenses 1200, 1202 focal lengths are almost the same. Thus the optical magnifications f_o/f_e are different in the left and right eye view. When combined with some form of optical shutter (not shown) such that only the left- or right-eye view 1207, 1209 is transmitted then one can observe different fields of view entering a single eye in each case. This effectively turns the modified binoculars into two monoculars with different magnifications, each connected to a different eye. So long as the user has equal viewing ability with both eyes then one may rapidly switch field of view by blocking the other direction from reaching the respective eyepiece.

As illustrated in figure 12, this concept can be taken a stage further by incorporating a part view transmitted through each eyepiece, similar to the example embodiment shown in figure 10, implemented using polarizers, liquid crystals or mechanical means (not shown), or similar to the example embodiments shown in figure 11a, using blocking elements (not shown). In figure 12, a partial view 1208, 1210 is shown in each eyepiece, with, in this example, the low magnification view in the right eyepiece only seeing the upper third of the full view, and the high magnification view in the left eyepiece seeing the lower two thirds of the full view. Now, when both eyes are used, the user perceives a split field of view 1212, as shown at the far right of figure 12.

Other example embodiments

In other example embodiments, the optical elements responsible for the two 90° reflections of the larger objective light (compare e.g. figure 6) may be a range of other optical components, including mirrors (which can make the viewing apparatus lighter), or a modified form of an elongated rhomboid prism 1300 combined with a beam splitter 1302 at one end, as shown in Figure 13. This has the advantage of having fewer surfaces to causes reflective losses, but the disadvantage of being heavier.

In other example embodiments, the process of multiple reflections to further increases the path length and so focal length than can be used/ magnification can be carried out more times, for example using a custom prism 1400 as illustrated in figure 14. Again, this has the advantage of having fewer surfaces to causes reflective losses compared to forming the same optical path using discrete components, but the disadvantage of being heavier.

While the example embodiments described above have focused on the use of cube beam splitters (CBS), plate beam splitters (PBS) may be used in different example embodiments, being significantly lighter.

The standard action of light passing through the central interface of a CBS or the tilted PBS (at 45 degrees) is that 50% of light is transmitted and the other 50% is reflected. Thus for the straight in line geometry in figure 6, for the low magnification channel, when the front shutter is open, 50% of light from the objective is transmitted to the Schmidt–Pechan Prism 602 and 50% is reflected upwards and is lost to the process. For the high magnification channel, when the side shutter is open, 50% of light is reflected and passes into the Schmidt–Pechan Prism 602 and 50% is transmitted upwards, and is lost to the process. Thus one penalty to pay for the switchable nature according to example embodiments is lower light intensity reaching the eyepiece, compared to standard binoculars. However, for both CBS and PBS one may choose the transmission to rejection (T:R) ratio and so tune the relatively brightness of the two FOV according to example embodiments.

The example embodiments described above use of some form of light shutter in the optical path of both viewing directions. Opening/closing these shutters allows light from different path ways into the common erecting prism and common eyepiece. Several forms of shutter might be used in various example embodiments, each with their own strengths and weaknesses, for example:

Liquid Crystal (LC) shutters: Suffer from an optical transmission of only ~50% and small distortion of the wave front. They also have a relatively low optical rejection ratio.

Mechanical shutters: can be driven electrically or by hand. These can provide the highest light transmission of 100% with zero distortion (light passes straight through) and infinite rejection ratio when “off” (all light is blocked by thick shutter). However, hand operated shutters are slow and probably difficult to operate, whereas electromechanical ones can be fast (down to milliseconds) but have a more complex driving mechanism

In an example embodiment, there is provided a viewing apparatus comprising a first objective lens having a first focal length; a second objective lens having a second focal length; and a common eyepiece lens having a third focal length or first and second eyepiece lenses having fourth and fifth focal lengths, respectively; wherein the viewing apparatus is configured, in a first viewing mode, that such an image viewable through the common eyepiece lens comprises, in different parts thereof, respective portions of respective fields of view, FOV, through the first objective lens and through the second objective lens with different magnifications, or a combined image viewable through the first and second eyepiece lenses simultaneously comprises, in different parts thereof, respective portions of respective fields of view, FOV, through the first objective lens and through the second objective lens with different magnifications.

The viewing apparatus may be configured, in a second viewing mode, such that the image viewable through the common eyepiece lens selectively comprises a field of view, FOV, through the first objective lens or through the second objective lens with different magnifications, or an image viewable through the first eyepiece lens comprises at least a portion of the FOV through the first objective lens and an image viewable through the second eyepiece lens comprises at least a portion of the FOV through the second objective lens at different magnifications.

The apparatus may comprise a combiner element for combining respective optical paths through the first and second objective lenses towards the common eyepiece lens. The apparatus may comprise a reflection element for directing an optical path through one of the first and second objective lenses towards the combiner element.

The apparatus may comprise a shutter element for selectively allowing only one of the respective optical paths through the first and second objective lenses to reach the common eyepiece lens.

The apparatus may comprise first and second polarizer elements for polarizing light from the FOV through the first and second objective lenses, respectively, and a third polarizer element configured for controlling a polarization of light viewed through the common eyepiece.

The third polarizer may comprise a rotatable linear polarizer.

The third polarizer element may comprise a split composition linear polarizer. The split composition linear polarizer may be moveable to change a mixture of the portions of the FOV through the first and second objective lenses, respectively, viewable through the common eyepiece.

The third polarizer element may be fixed and the apparatus may further comprise a liquid crystal layer for altering a polarization of light viewable through the common eyepiece for switching between the FOV through the first objective lens or through the second objective lens.

The apparatus may comprise first and second blocking elements for blocking respective portions of the FOV through the first and second objective lenses from reaching the common eyepiece of the first and second eyepieces.

The apparatus may comprise at least one diverting element for diverting the FOV through one of the first and second objective lenses relative to the FOV of the other one.

The apparatus may comprise at least one extending element for extending an optical path length within the apparatus.

In an example embodiment, there is provided a viewing apparatus comprising a first objective lens having a first focal length; a second objective lens having a second focal length; a common eyepiece lens having a third focal length; a combiner element for combining respective optical paths through the first and second objective lenses into a common optical paths towards the common eyepiece lens; first and second polarizer elements disposed in the first and second optical paths, respectively, and having different polarization orientations; and a liquid crystal element and a third polarizer element disposed in the common optical path; wherein the viewing apparatus is configured that such: depending on a polarization alternating state of the liquid crystal, an image viewable through the common eyepiece lens selectively comprises a field of view, FOV, through the first objective lens or through the second objective lens with different magnifications.

Figure 15 shows a flowchart 1500 illustrating a method of providing different fields of view via one or more eyepieces, according to an example embodiment. At step 1502, a first objective lens having a first focal length is provided. At step 1504 a second objective lens having a second focal length is provided. At step 1506a , a common eyepiece lens having a third focal length is provided or , at step 1506b, first and second eyepiece lenses having fourth and fifth focal lengths, respectively, are provided. At step 1508a, in a first viewing mode, a first image viewable through the common eyepiece lens is provided which comprises, in different parts thereof, respective portions of respective fields of view, FOV, through the first objective lens and through the second objective lens with different magnifications, or, at step 1508b, a combined image viewable through the first and second eyepiece lenses simultaneously is provided which comprises, in different parts thereof, respective portions of respective fields of view, FOV, through the first objective lens and through the second objective lens with different magnifications.

The method may comprise, in a second viewing mode, providing a second image viewable through the common eyepiece lens which selectively comprises a field of view, FOV, through the first objective lens or through the second objective lens with different magnifications, or providing a third image viewable through the first eyepiece lens comprises at least a portion of the FOV through the first objective lens and providing a fourth image viewable through the second eyepiece lens comprises at least a portion of the FOV through the second objective lens at different magnifications.

The method may comprise combining respective optical paths through the first and second objective lenses towards the common eyepiece lens. The method may comprise directing an optical path through one of the first and second objective lenses towards the combiner element.

The method may comprise selectively allowing only one of the respective optical paths through the first and second objective lenses to reach the common eyepiece lens.

The method may comprise polarizing light from the FOV through the first and second objective lenses, respectively, and controlling a polarization of light viewed through the common eyepiece.

The method may comprise blocking respective portions of the FOV through the first and second objective lenses from reaching the common eyepiece of the first and second eyepieces.

The method may comprise diverting the FOV through one of the first and second objective lenses relative to the FOV of the other one.

The method may comprise extending an optical path length within the apparatus.

Figure 16 shows a flowchart 1600 illustrating a method of providing a view via an eyepiece, according to an example embodiment. At step 1602, a first objective lens having a first focal length is provided. At step 1604, a second objective lens having a second focal length is provided. At step 1606. a common eyepiece lens having a third focal length is provided. At step 1608. a combiner element is provided for combining respective optical paths through the first and second objective lenses into a common optical paths towards the common eyepiece lens. At step 1610. first and second polarizer elements disposed in the first and second optical paths, respectively, and having different polarization orientations are provided. At step 1612, a liquid crystal element and a third polarizer element disposed in the common optical path are provided. At step 1614, depending on an polarization alternating state of the liquid crystal, an image viewable through the common eyepiece lens is provided which selectively comprises a field of view, FOV, through the first objective lens or through the second objective lens with different magnifications.

Embodiments of The present invention can have one or more of the following features and associated benefits/advantages:

Feature	Benefit/Advantage
Use of some forms of shutters in conjunction with cube beam splitter to provide choice of different magnification views	Simple components to greatly enhance functionality of all forms of refracting telescope
Specifically using linear polarizers and liquid crystal light shutters to allow rapid selection of the field of view transmitted to the eyepiece	Simple components to greatly enhance functionality of all forms of refracting telescope
Rapid switching between different magnification views in all variations of refracting telescope, including telescopic sights, monoculars and binoculars	Allows features of interest to be identified at low magnification and then viewed at high magnification with rapid change.
Use of linear polarizers to provide split view in eyepiece, so that partial views at two different magnifications can be seen simultaneously	Allows features of interest to be identified at low magnification and then viewed at high magnification without any change of view.

Use of extended light path to increase optical magnification.	Better performance without increasing instrument length

Applications for example embodiments of the present invention exploit allowing an optically magnifying instrument, such as monoculars, binoculars, spotter scopes or telescopic sights, to rapidly switch between different FOV, or to observe both FOV simultaneously. This can be very helpful, for example using binoculars at high magnification to view birds. Having the option to rapidly switch to, or simultaneously observe a wider FOV can be a big help, allowing interesting objects outside the narrow FOV to be rapidly located and centred, for viewing at high magnification without having to randomly move around the instrument.

Aspects of the systems and methods described herein, such as the control of light shutters and/or polarizers, may be implemented as functionality programmed into any of a variety of circuitry, including programmable logic devices (PLDs), such as field programmable gate arrays (FPGAs), programmable array logic (PAL) devices, electrically programmable logic and memory devices and standard cell-based devices, as well as application specific integrated circuits (ASICs). Some other possibilities for implementing aspects of the system include: microcontrollers with memory (such as electronically erasable programmable read only memory (EEPROM)), embedded microprocessors, firmware, software, etc. Furthermore, aspects of the system may be embodied in microprocessors having software-based circuit emulation, discrete logic (sequential and combinatorial), custom devices, fuzzy (neural) logic, quantum devices, and hybrids of any of the above device types. Of course the underlying device technologies may be provided in a variety of component types, e.g., metal-oxide semiconductor field-effect transistor (MOSFET) technologies like complementary metal-oxide semiconductor (CMOS), bipolar technologies like emitter-coupled logic (ECL), polymer technologies (e.g., silicon-conjugated polymer and metal-conjugated polymer-metal structures), mixed analog and digital, etc.

The above description of illustrated embodiments of the systems and methods is not intended to be exhaustive or to limit the systems and methods to the precise forms disclosed. While specific embodiments of, and examples for, the systems components and methods are described herein for illustrative purposes, various equivalent modifications are possible within the scope of the systems, components and methods, as those skilled in the relevant art will recognize. The teachings of the systems and methods provided herein can be applied to other processing systems and methods, not only for the systems and methods described above.

It will be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

Also, the invention includes any combination of features described for different embodiments, including in the summary section, even if the feature or combination of features is not explicitly specified in the claims or the detailed description of the present embodiments.

In general, in the following claims, the terms used should not be construed to limit the systems and methods to the specific embodiments disclosed in the specification and the claims, but should be construed to include all processing systems that operate under the claims. Accordingly, the systems and methods are not limited by the disclosure, but instead the scope of the systems and methods is to be determined entirely by the claims.

Unless the context clearly requires otherwise, throughout the description and the claims, the words "comprise," "comprising," and the like are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense; that is to say, in a sense of "including, but not limited to." Words using the singular or plural number also include the plural or singular number respectively. Additionally, the words "herein," "hereunder," "above," "below," and words of similar import refer to this application as a whole and not to any particular portions of this application. When the word "or" is used in reference to a list of two or more items, that word covers all of the following interpretations of the word: any of the items in the list, all of the items in the list and any combination of the items in the list.

CLAIMS

1. A viewing apparatus comprising:

a first objective lens having a first focal length;

a second objective lens having a second focal length; and

a common eyepiece lens having a third focal length or first and second eyepiece lenses having fourth and fifth focal lengths, respectively;

wherein the viewing apparatus is configured, in a first viewing mode, that such:

an image viewable through the common eyepiece lens comprises, in different parts thereof, respective portions of respective fields of view, FOV, through the first objective lens and through the second objective lens with different magnifications, or

a combined image viewable through the first and second eyepiece lenses simultaneously comprises, in different parts thereof, respective portions of respective fields of view, FOV, through the first objective lens and through the second objective lens with different magnifications.

2. The viewing apparatus of claim 1, configured, in a second viewing mode, such that:

the image viewable through the common eyepiece lens selectively comprises a field of view, FOV, through the first objective lens or through the second objective lens with different magnifications, or

an image viewable through the first eyepiece lens comprises at least a portion of the FOV through the first objective lens and an image viewable through the second eyepiece lens comprises at least a portion of the FOV through the second objective lens at different magnifications.

3. The apparatus of claims 1 or 2, comprising a combiner element for combining respective optical paths through the first and second objective lenses towards the common eyepiece lens.

4. The apparatus of claim 3, comprising a reflection element for directing an optical path through one of the first and second objective lenses towards the combiner element.

5. The apparatus of any one of claims 1 to 4, comprising a shutter element for selectively allowing only one of the respective optical paths through the first and second objective lenses to reach the common eyepiece lens.

6. The apparatus of any one of claims 1 to 5, comprising first and second polarizer elements for polarizing light from the FOV through the first and second objective lenses, respectively, and a third polarizer element configured for controlling a polarization of light viewed through the common eyepiece.

7. The apparatus of claim 6, wherein the third polarizer comprises a rotatable linear polarizer.

8. The apparatus of claim 6, wherein the third polarizer element comprises a split composition linear polarizer.

9. The apparatus of claim 8, wherein the split composition linear polarizer is moveable to change a mixture of the portions of the FOV through the first and second objective lenses, respectively, viewable through the common eyepiece.

10. The apparatus of claim 6, wherein the third polarizer element is fixed and the apparatus further comprises a liquid crystal layer for altering a polarization of light viewable through the common eyepiece for switching between the FOV through the first objective lens or through the second objective lens.

11. The apparatus of any one of claims 1 to 10, comprising first and second blocking elements for blocking respective portions of the FOV through the first and second objective lenses from reaching the common eyepiece of the first and second eyepieces.

12. The apparatus of any one of claims 1 to 11, comprising at least one diverting element for diverting the FOV through one of the first and second objective lenses relative to the FOV of the other one.

13. The apparatus of any one of claims 1 to 12, comprising at least one extending element for extending an optical path length within the apparatus.

14. In accordance with a second aspect of the present invention, there is provided a viewing apparatus comprising:

a first objective lens having a first focal length;

a second objective lens having a second focal length;

a common eyepiece lens having a third focal length;

a combiner element for combining respective optical paths through the first and second objective lenses into a common optical paths towards the common eyepiece lens;

first and second polarizer elements disposed in the first and second optical paths, respectively, and having different polarization orientations; and

a liquid crystal element and a third polarizer element disposed in the common optical path;

wherein the viewing apparatus is configured that such:

depending on a polarization alternating state of the liquid crystal, an image viewable through the common eyepiece lens selectively comprises a field of view, FOV, through the first objective lens or through the second objective lens with different magnifications.

15. A method of providing different fields of view via one or more eyepieces, the method comprising the steps of:

providing a first objective lens having a first focal length;

providing a second objective lens having a second focal length; and

providing a common eyepiece lens having a third focal length or providing first and second eyepiece lenses having fourth and fifth focal lengths, respectively;

and providing, in a first viewing mode:

a first image viewable through the common eyepiece lens which comprises, in different parts thereof, respective portions of respective fields of view, FOV, through the first objective lens and through the second objective lens with different magnifications, or

a combined image viewable through the first and second eyepiece lenses simultaneously which comprises, in different parts thereof, respective portions of respective fields of view, FOV, through the first objective lens and through the second objective lens with different magnifications.

16. The method of claim 15, comprising, in a second viewing mode:

providing a second image viewable through the common eyepiece lens which selectively comprises a field of view, FOV, through the first objective lens or through the second objective lens with different magnifications, or

providing a third image viewable through the first eyepiece lens comprises at least a portion of the FOV through the first objective lens and providing a fourth image viewable through the second eyepiece lens comprises at least a portion of the FOV through the second objective lens at different magnifications.

17. The method of claims 15 or 16, comprising combining respective optical paths through the first and second objective lenses towards the common eyepiece lens.

18. The method of claim 17, comprising directing an optical path through one of the first and second objective lenses towards the combiner element.

19. The method of any one of claims 15 to 18, comprising selectively allowing only one of the respective optical paths through the first and second objective lenses to reach the common eyepiece lens.

20. The method of any one of claims 15 to 19, comprising polarizing light from the FOV through the first and second objective lenses, respectively, and controlling a polarization of light viewed through the common eyepiece.

21. The method of any one of claims 15 to 20, comprising blocking respective portions of the FOV through the first and second objective lenses from reaching the common eyepiece of the first and second eyepieces.

22. The method of any one of claims 15 to 21, comprising diverting the FOV through one of the first and second objective lenses relative to the FOV of the other one.

23. The method of any one of claims 15 to 22, comprising extending an optical path length within the apparatus.

24. A method of providing a view via an eyepiece, the method comprising the steps of:

providing a first objective lens having a first focal length;

providing a second objective lens having a second focal length;

providing a common eyepiece lens having a third focal length;

providing a combiner element for combining respective optical paths through the first and second objective lenses into a common optical paths towards the common eyepiece lens;

providing first and second polarizer elements disposed in the first and second optical paths, respectively, and having different polarization orientations;

providing a liquid crystal element and a third polarizer element disposed in the common optical path; and

depending on a polarization alternating state of the liquid crystal, providing an image viewable through the common eyepiece lens which selectively comprises a field of view, FOV, through the first objective lens or through the second objective lens with different magnifications.

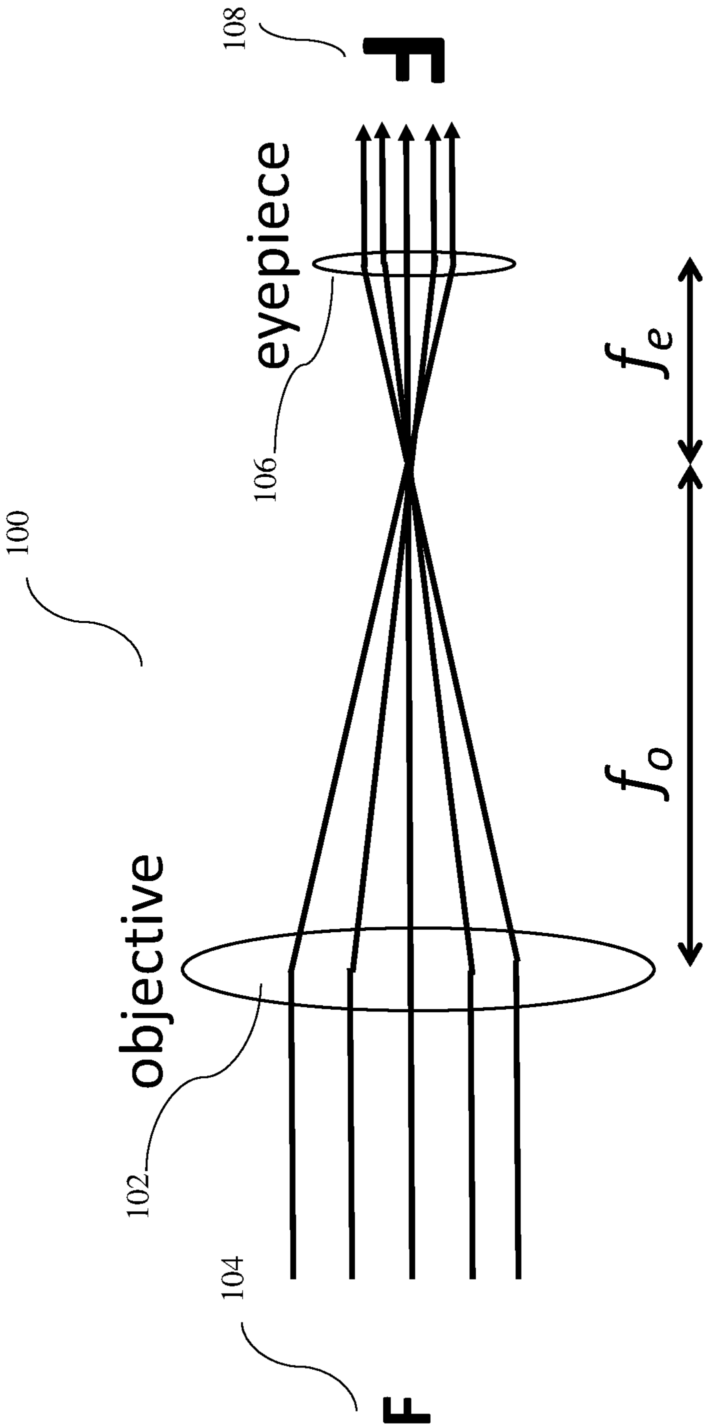


Figure 1

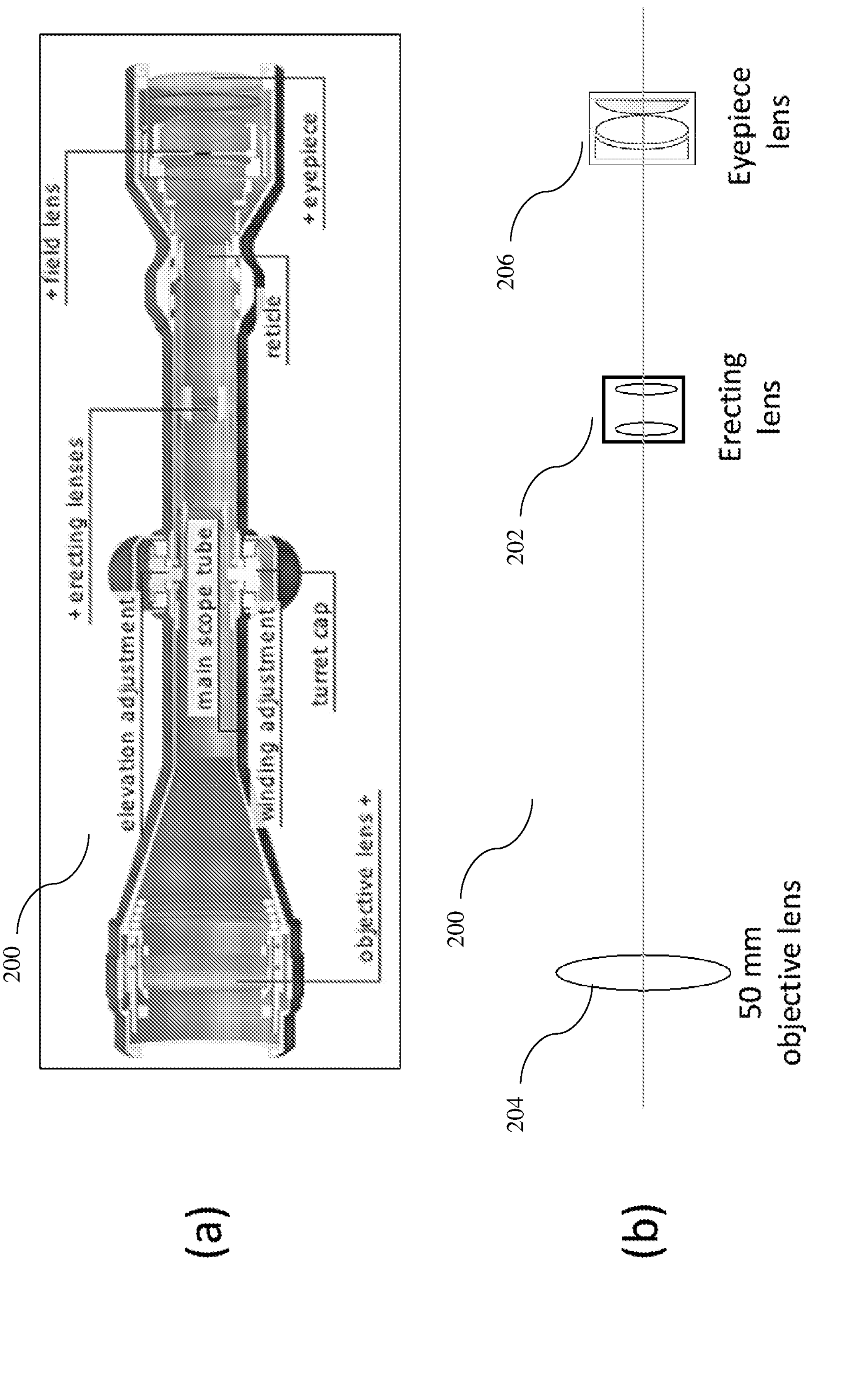

(a)
200
+ field lens
+ eyepiece
reticle
+ erecting lenses
elevation adjustment
main scope tube
winding adjustment
turret cap
objective lens +
(b)
200
202
204
206
50 mm
objective lens
Erecting
lens
Eyepiece
lens

Figure 2

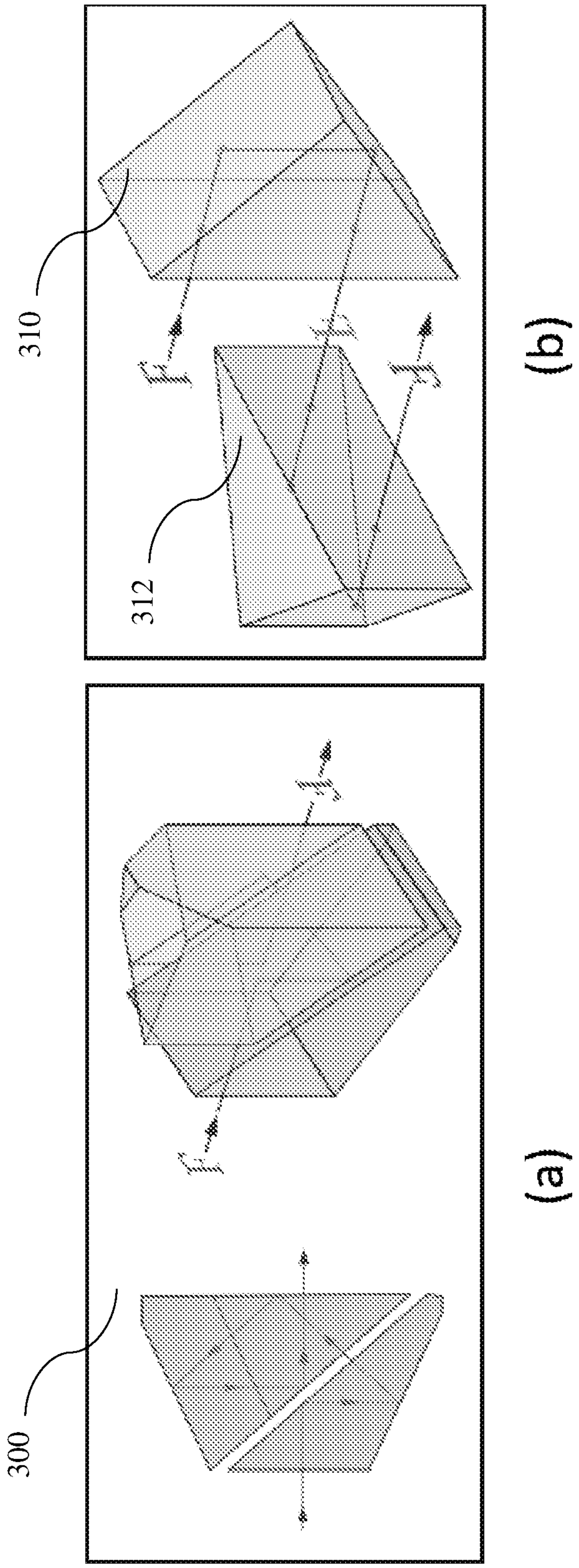


Figure 3

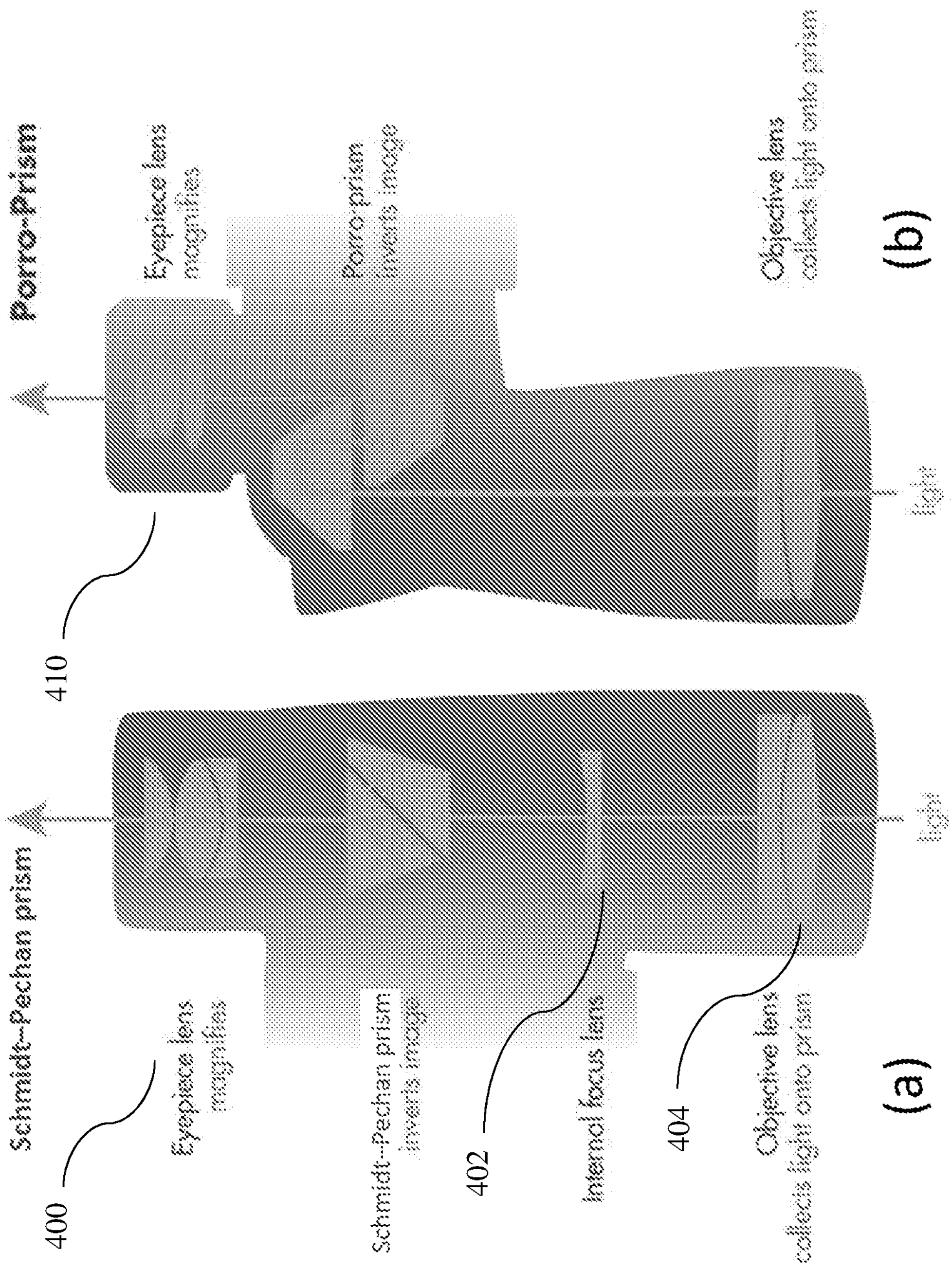

400
Schmidt–Pechan prism
Eyepiece lens magnifies
Schmidt–Pechan prism inverts image
402
Internal focus lens
404
Objective lens collects light onto prism
light
(a)
410
Porro-Prism
Eyepiece lens magnifies
Porro prism inverts image
Objective lens collects light onto prism
light
(b)

Figure 4

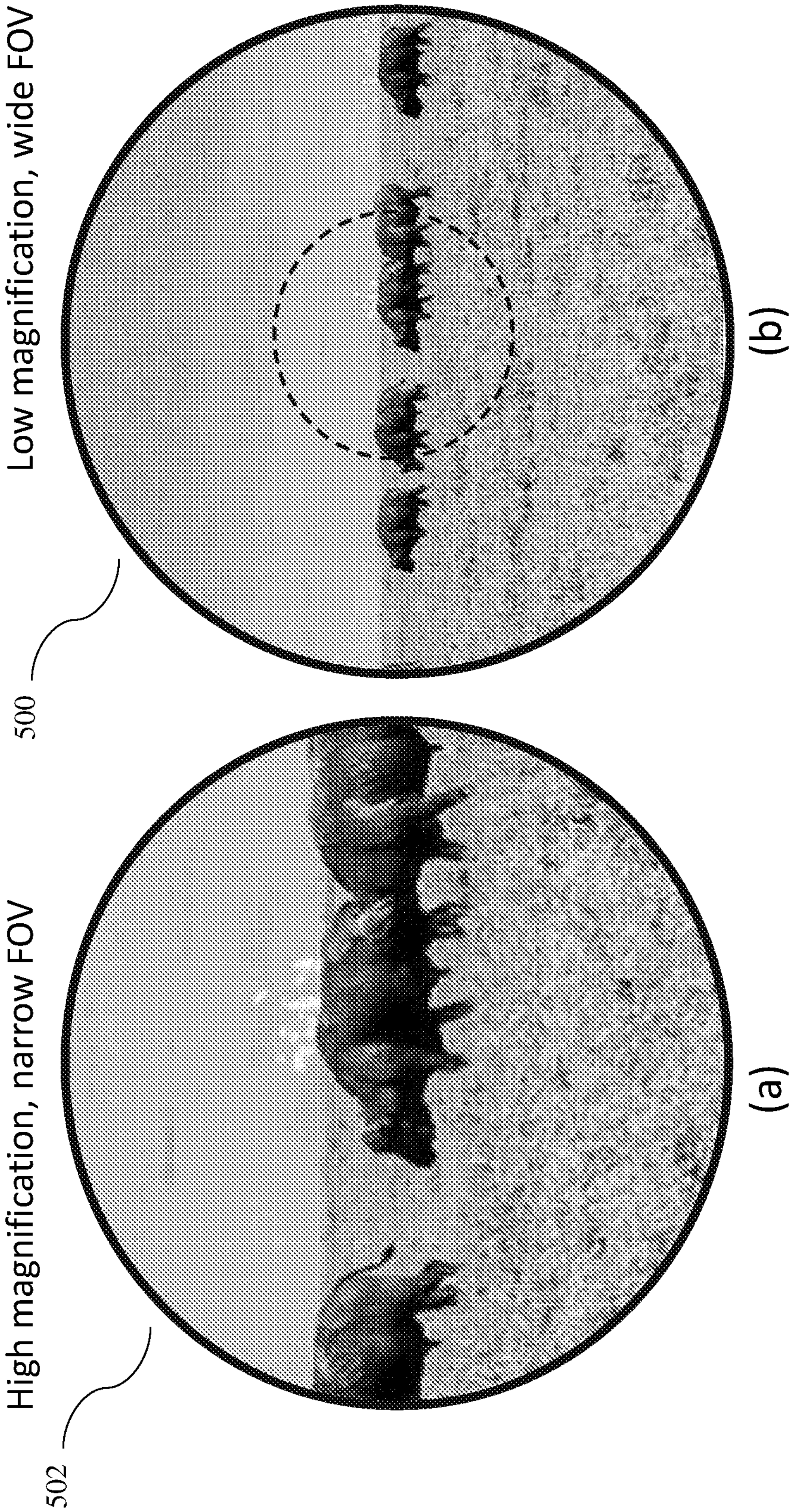

Low magnification, wide FOV
500
(b)
High magnification, narrow FOV
502
(a)

Figure 5

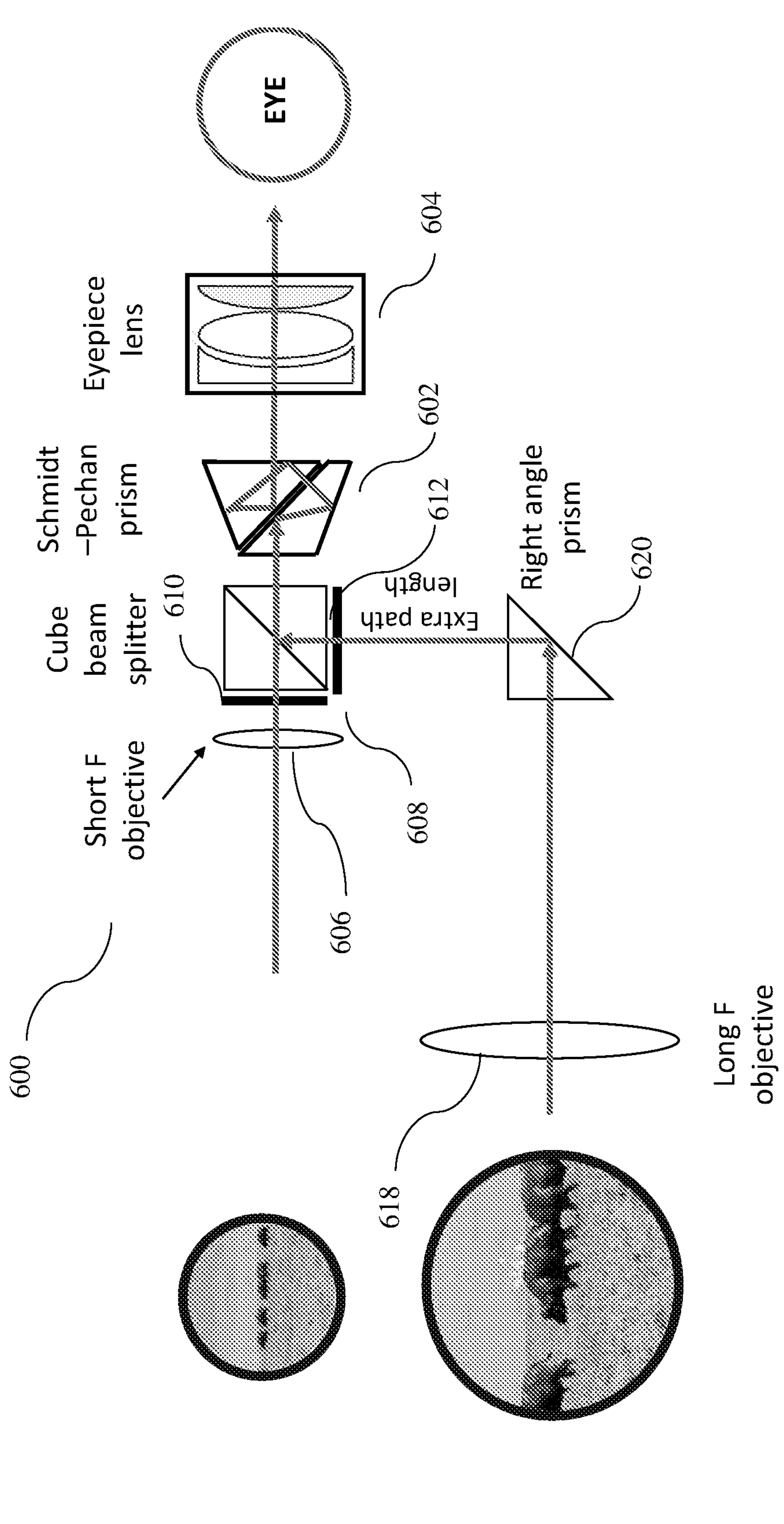

EYE
604
Eyepiece
lens
602
Schmidt
–Pechan
prism
612
Cube
beam
splitter
610
Extra path
length
Right angle
prism
620
Short F
objective
606
608
600
Long F
objective
618

Figure 6

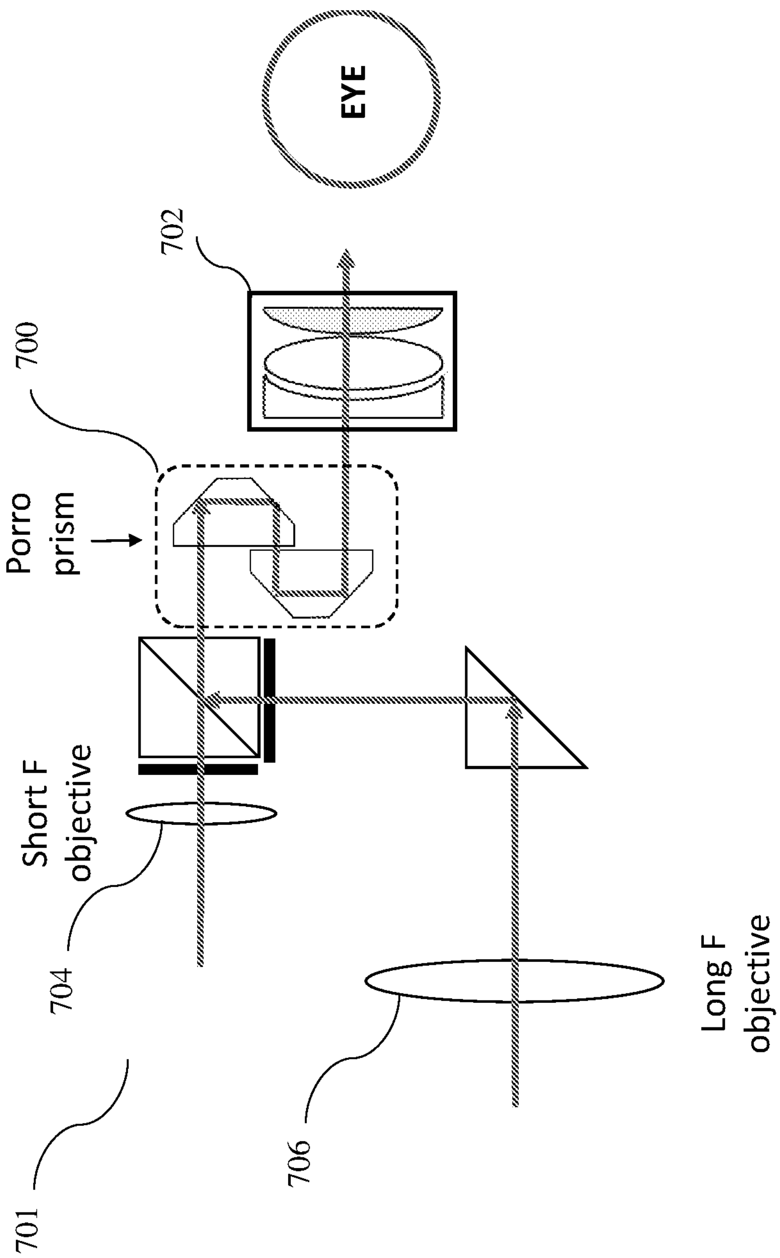

EYE
702
700
Porro prism
Short F objective
704
701
706
Long F objective

Figure 7(a)

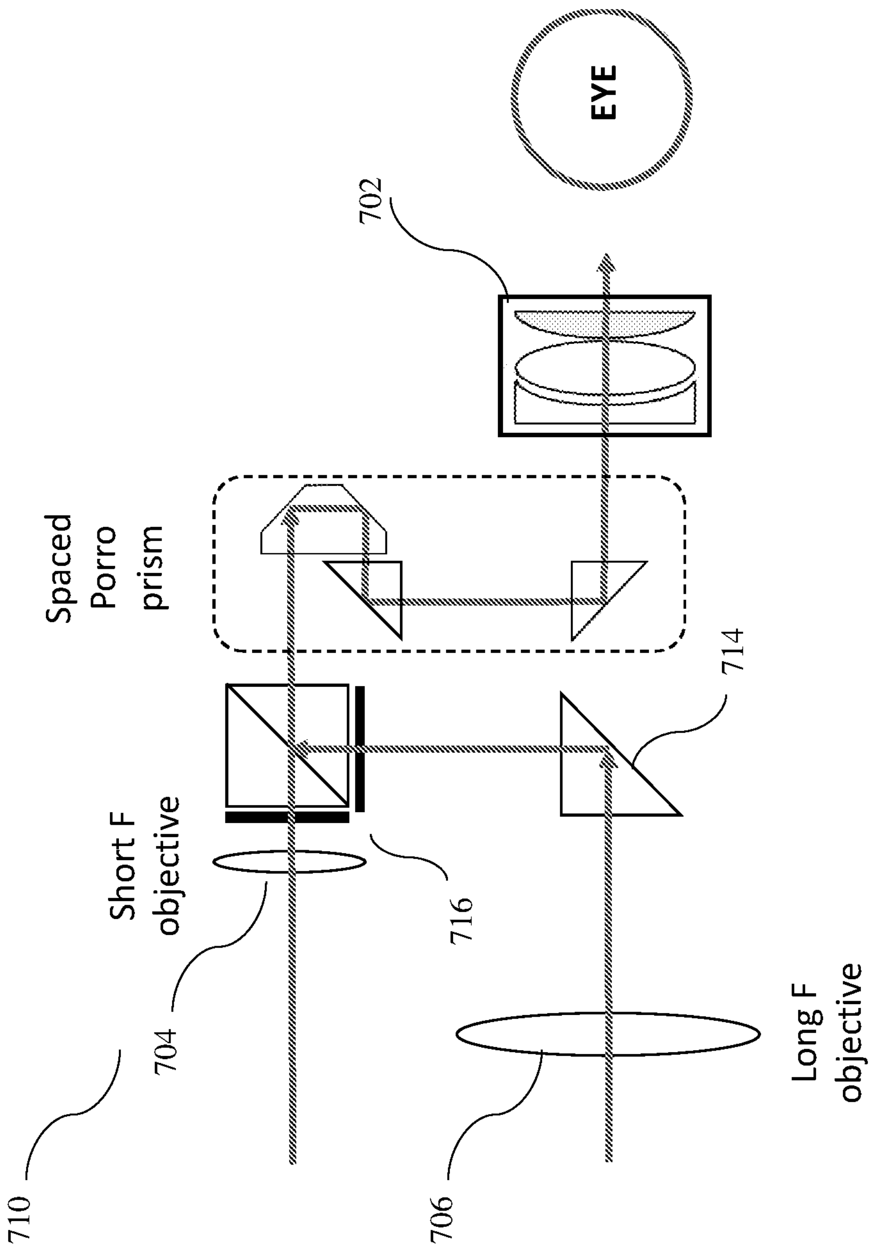

EYE
702
Spaced
Porro
prism
714
Short F
objective
716
704
710
706
Long F
objective

Figure 7(b)

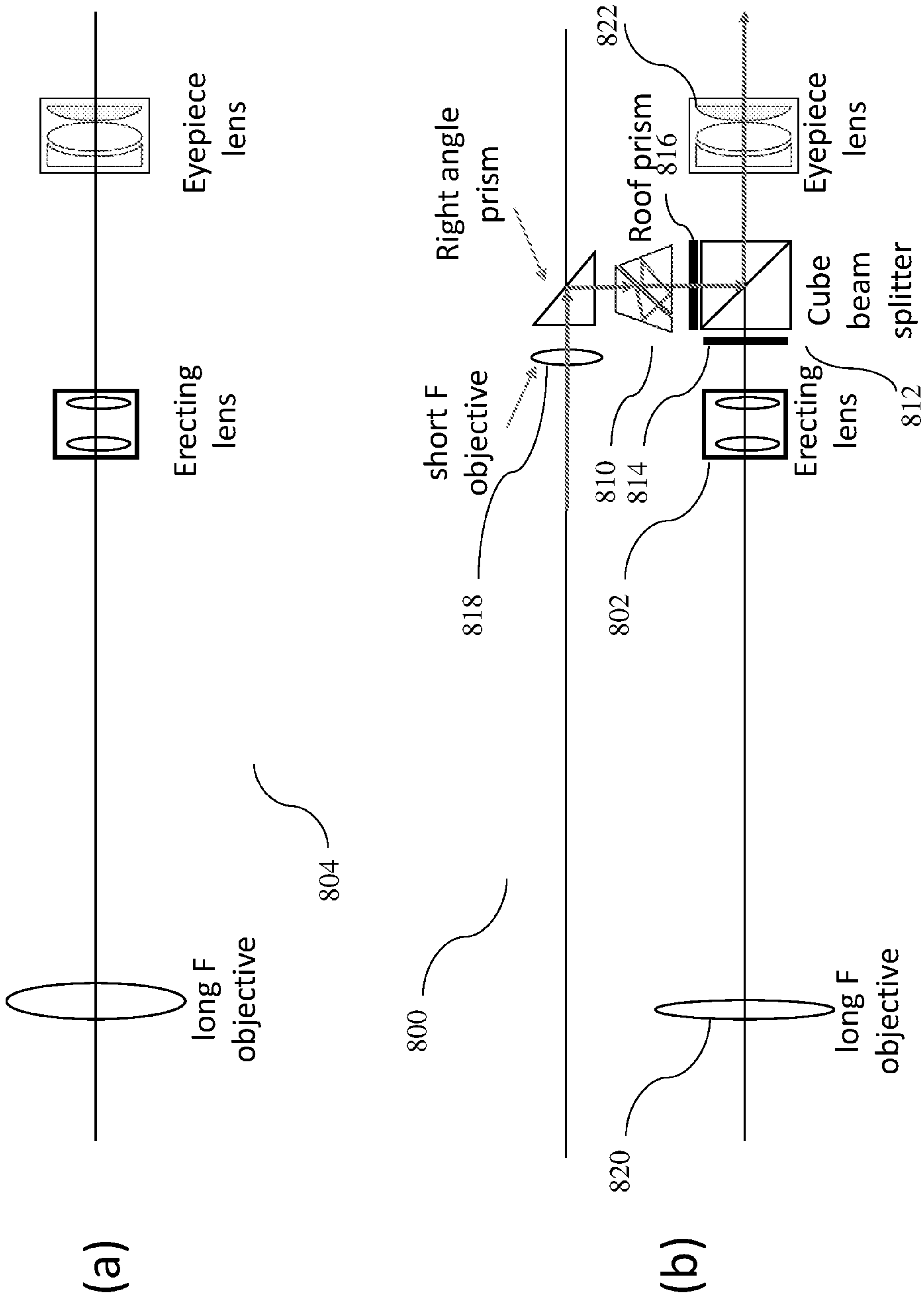

(a)
long F objective
804
Erecting lens
Eyepiece lens
(b)
820
long F objective
800
818
short F objective
Right angle prism
Roof prism
816
810
814
802
Erecting lens
Cube beam splitter
812
Eyepiece lens
822

Figure 8

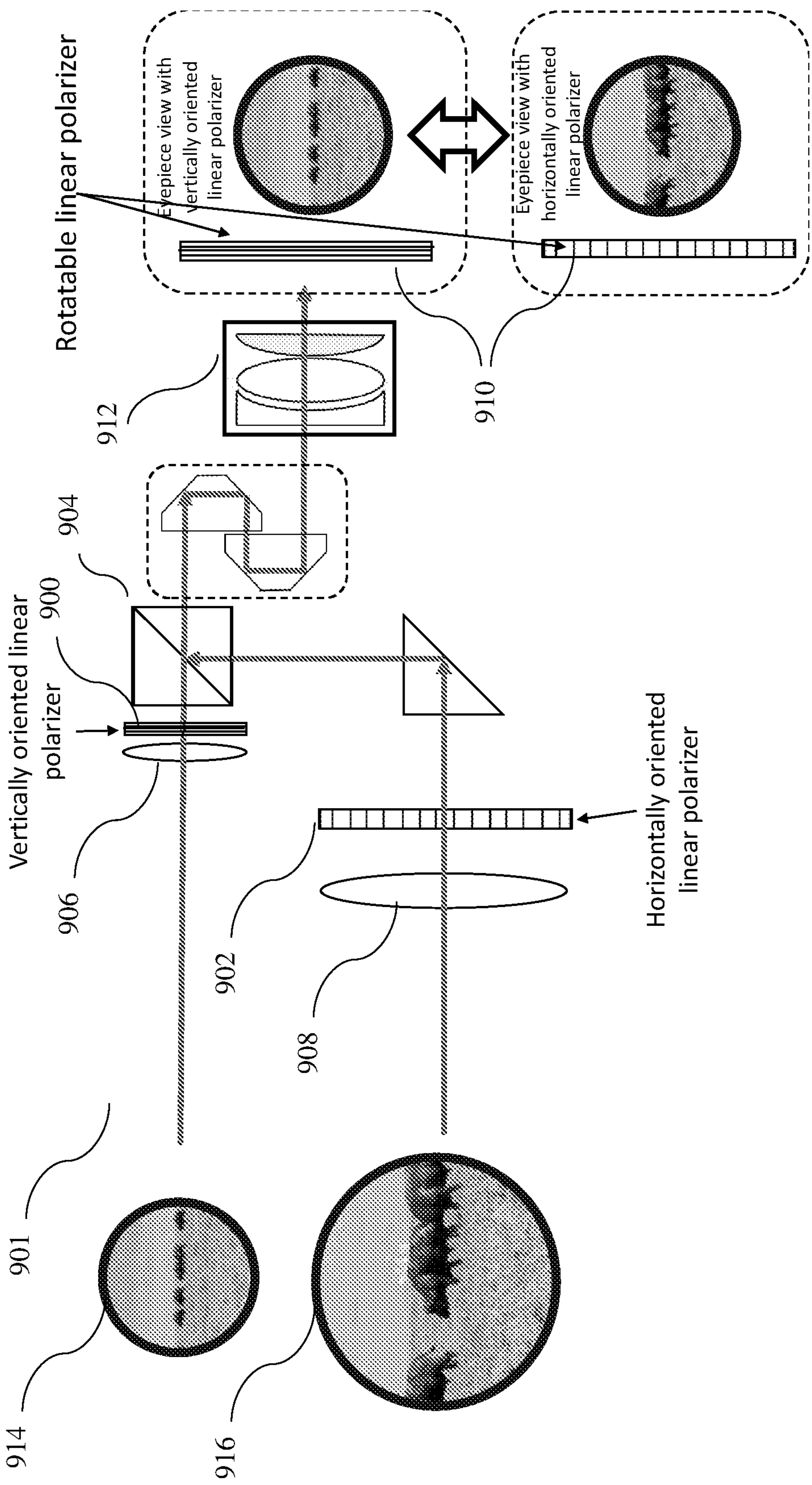

Rotatable linear polarizer
Eyepiece view with vertically oriented linear polarizer
Eyepiece view with horizontally oriented linear polarizer
912
910
904
900
Vertically oriented linear polarizer
906
902
Horizontally oriented linear polarizer
908
901
914
916

Figure 9(a)

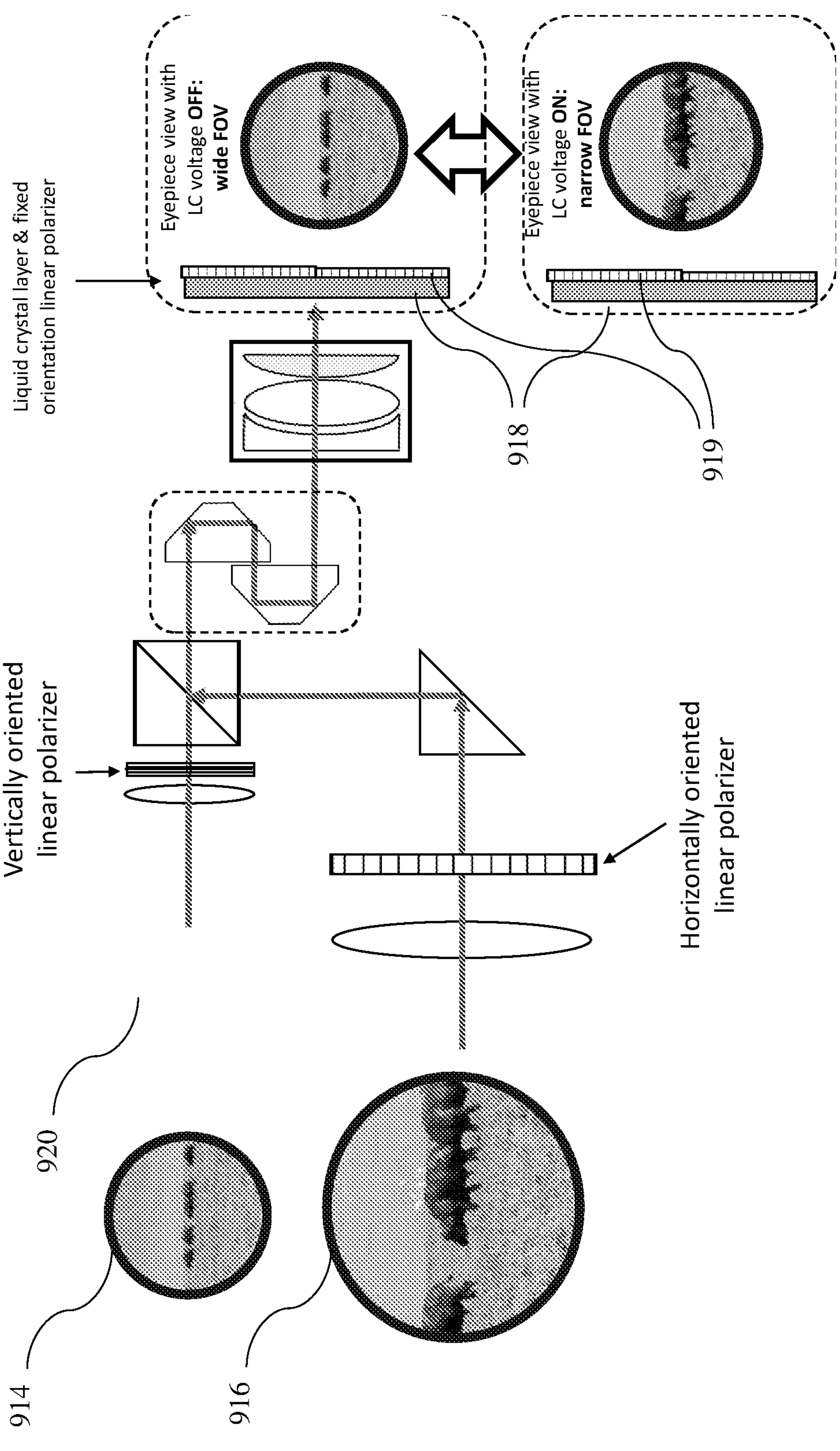
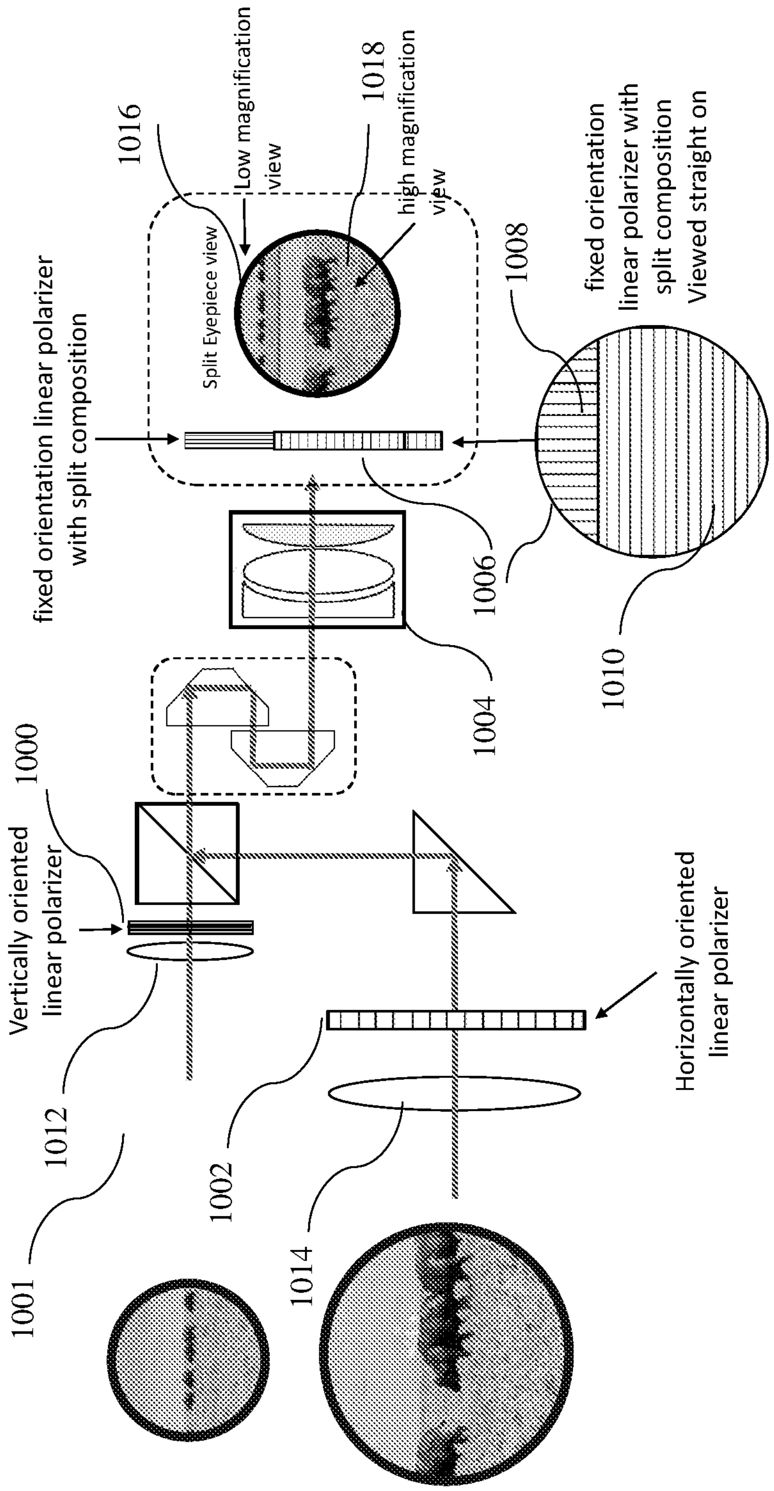

Liquid crystal layer & fixed orientation linear polarizer
Eyepiece view with LC voltage **OFF:** **wide FOV**
Eyepiece view with LC voltage **ON:** **narrow FOV**
918
919
Vertically oriented linear polarizer
Horizontally oriented linear polarizer
920
914
916

Figure 9(b)



1016
Low magnification view
1018
high magnification view
Split Eyepiece view
fixed orientation linear polarizer with split composition
1008
fixed orientation linear polarizer with split composition Viewed straight on
1006
1010
1004
1000
Vertically oriented linear polarizer
1012
1001
1002
Horizontally oriented linear polarizer
1014

Figure 10

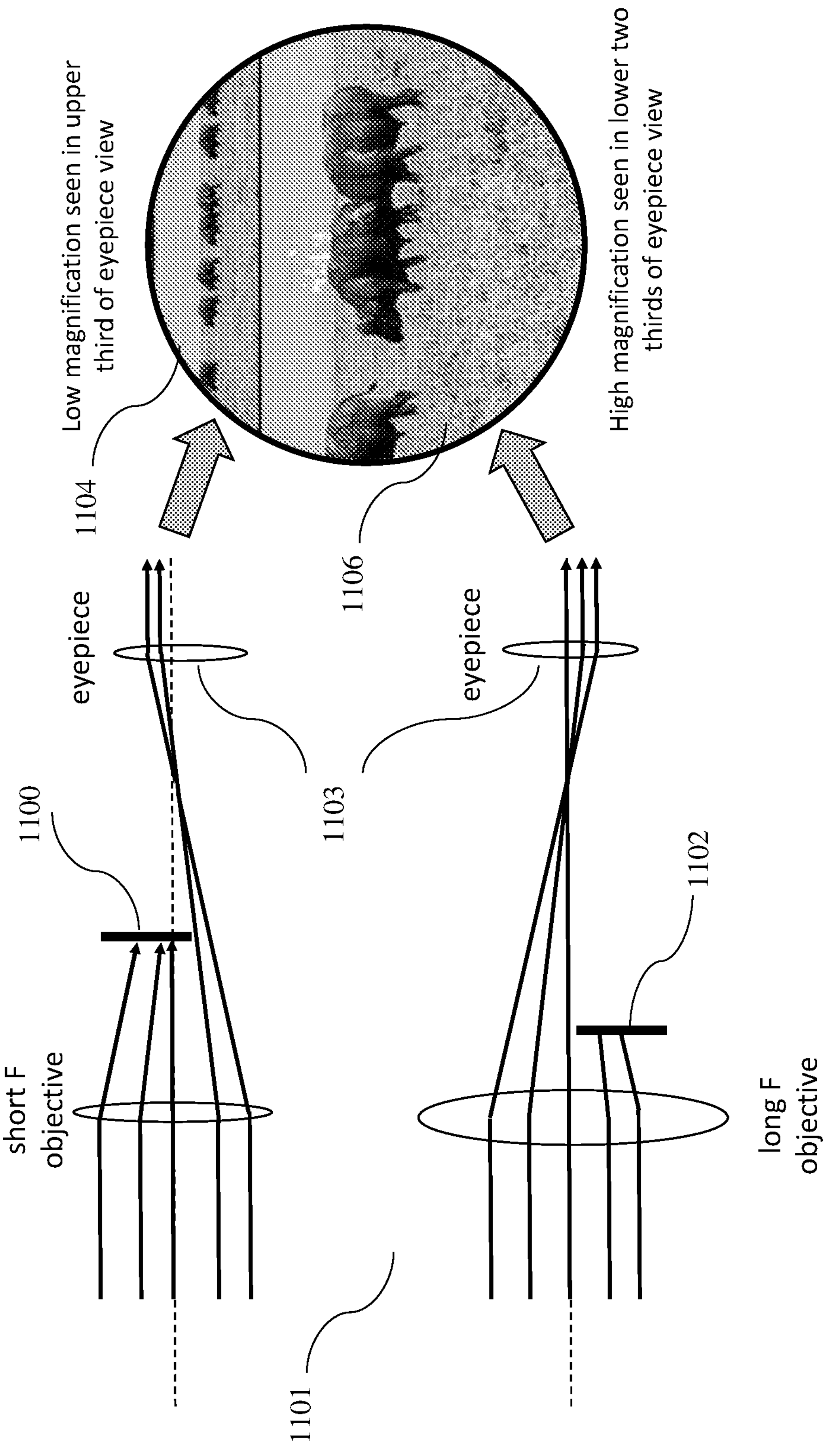

Low magnification seen in upper third of eyepiece view
High magnification seen in lower two thirds of eyepiece view
1104
1106
eyepiece
eyepiece
1103
1100
1102
short F objective
long F objective
1101

Figure 11(a)

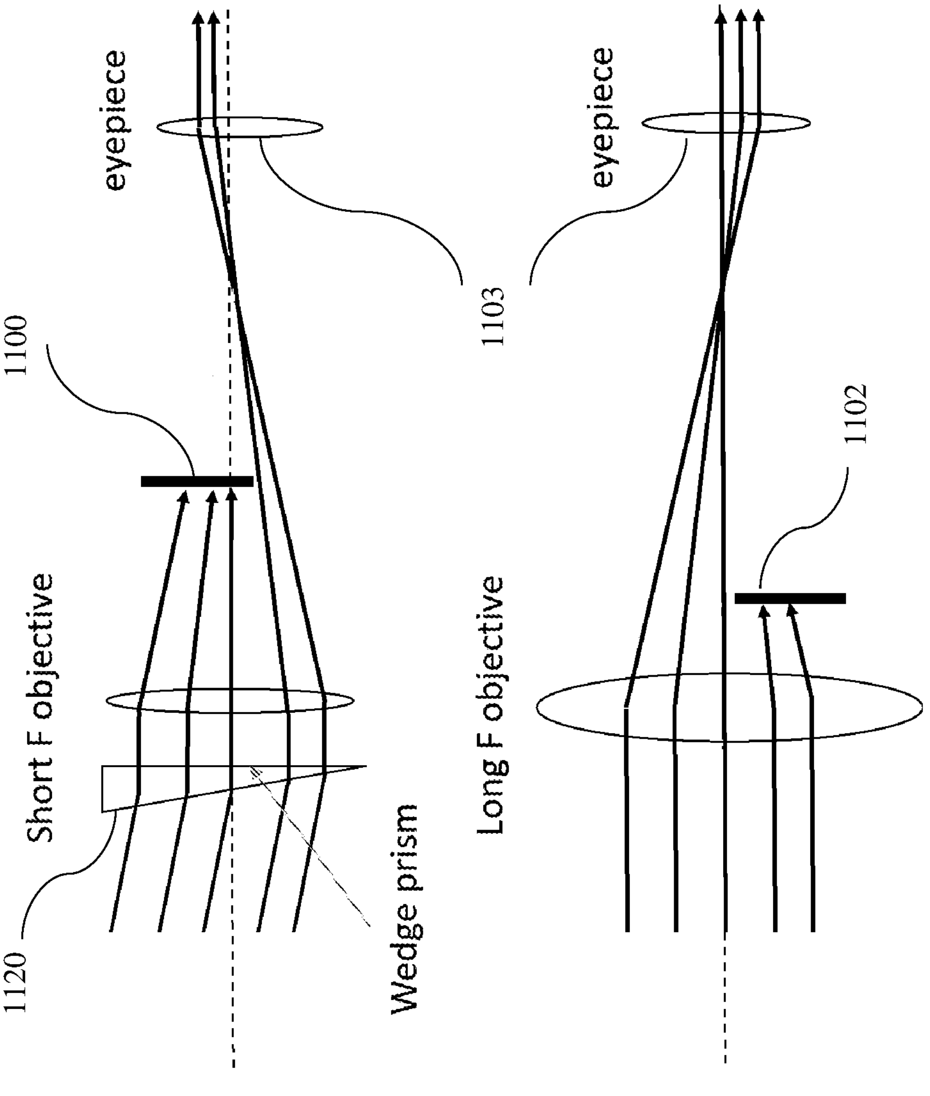

eyepiece
1100
1103
Short F objective
1120
Wedge prism
eyepiece
1102
Long F objective

Figure 11(b)

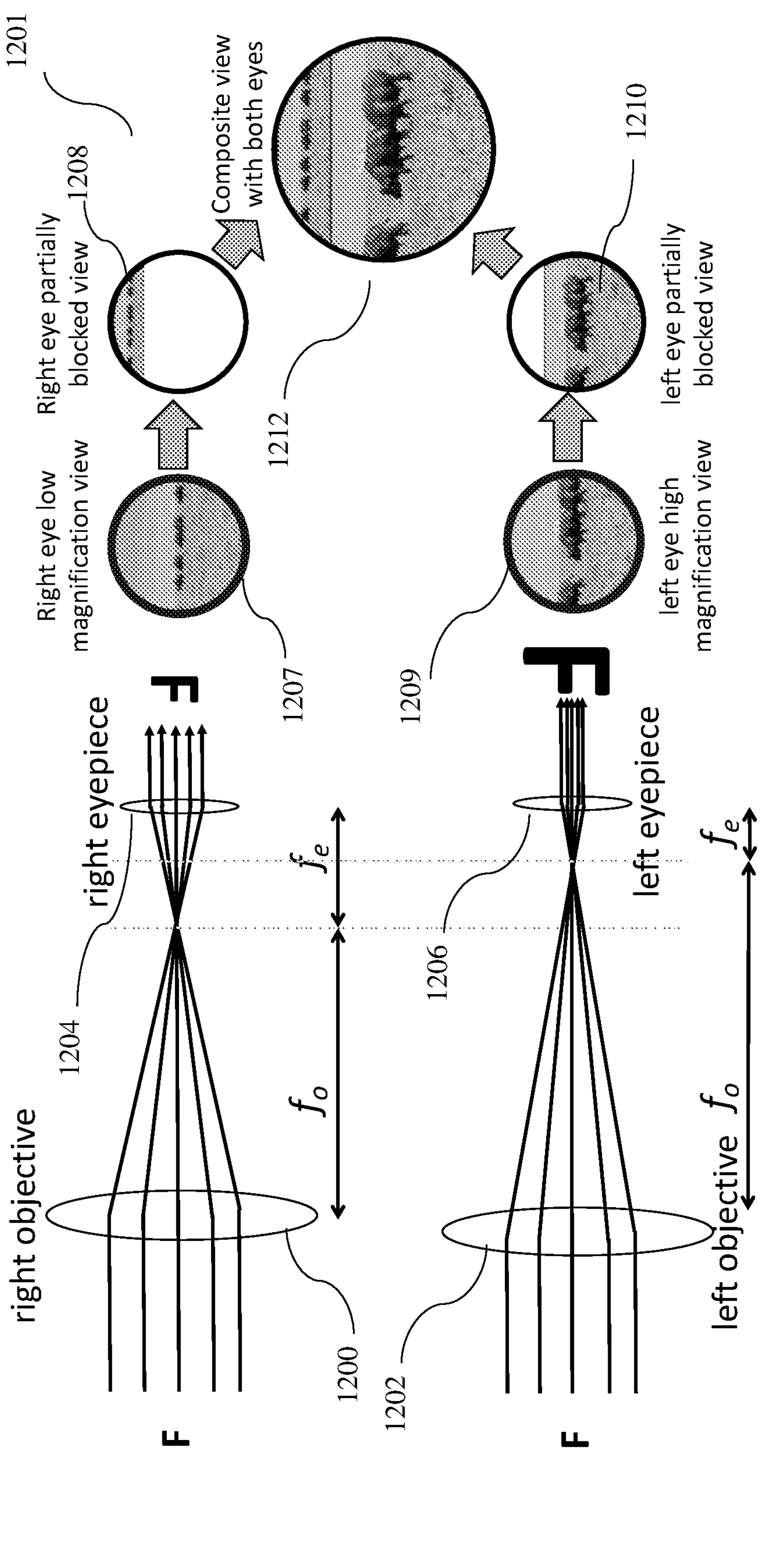

1201
Right eye low magnification view
Right eye partially blocked view
1208
Composite view with both eyes
1210
1212
1207
left eye high magnification view
left eye partially blocked view
1209
right eyepiece
right objective
1204
1206
left eyepiece
left objective
f_o
f_e
1200
1202
F

Figure 12

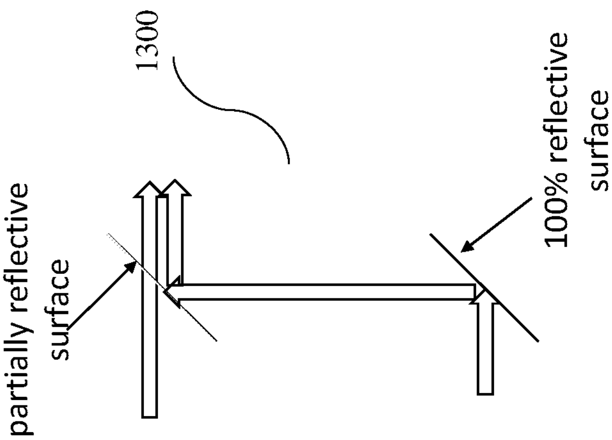


Figure 13

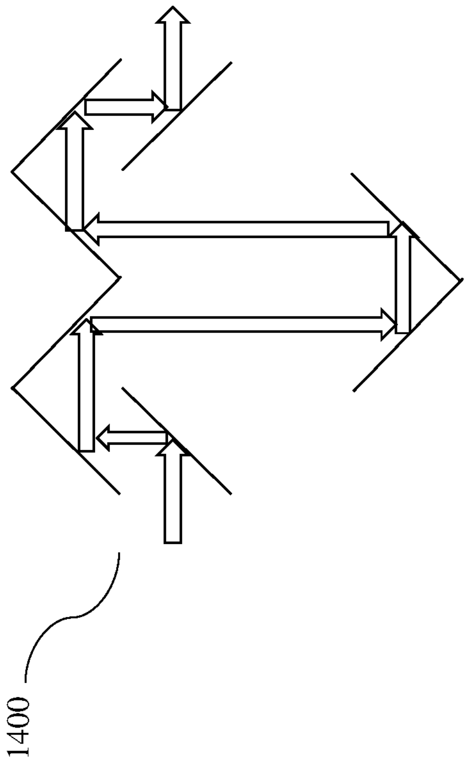


Figure 14

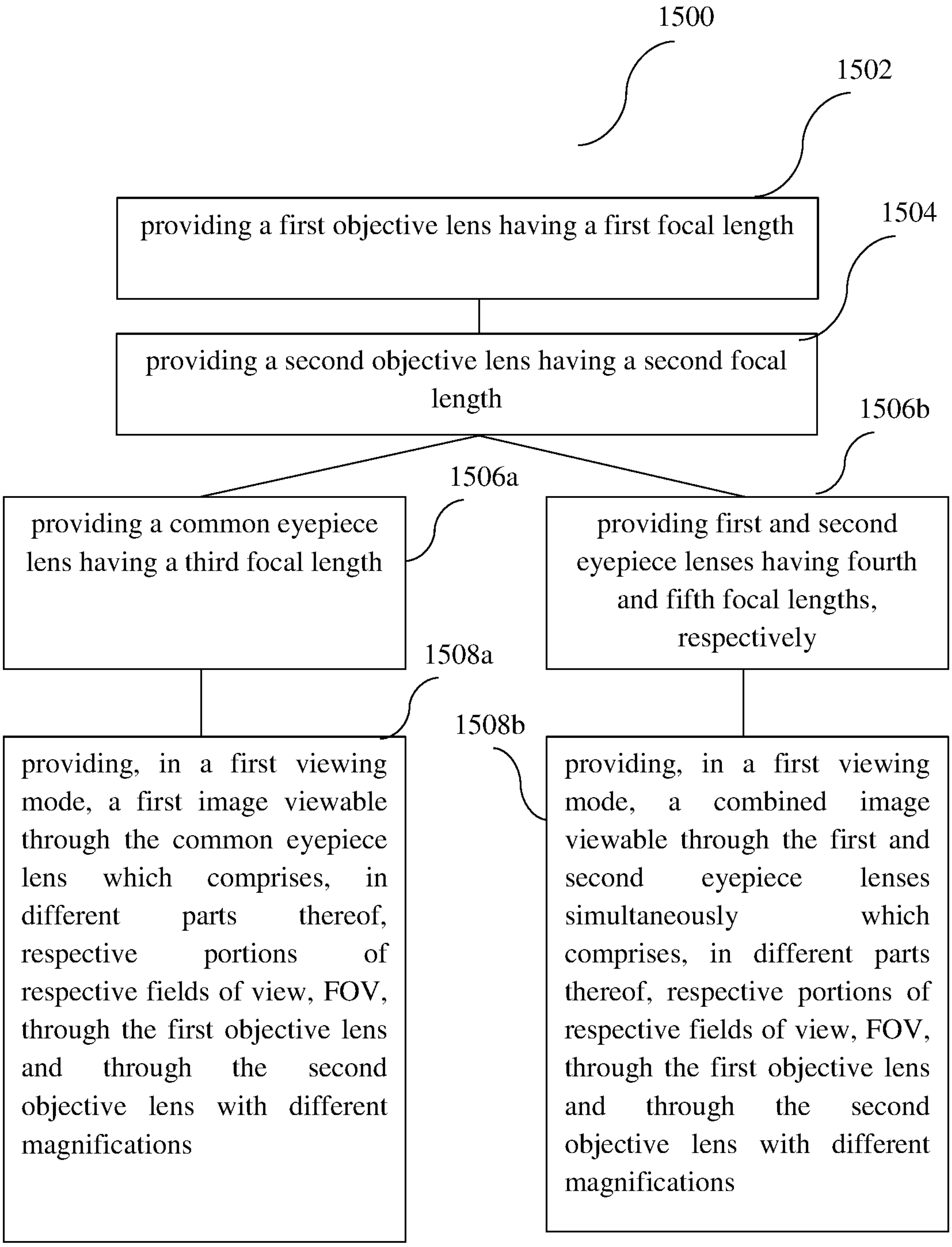

1500
1502
providing a first objective lens having a first focal length
1504
providing a second objective lens having a second focal length
1506b
1506a
providing a common eyepiece lens having a third focal length
providing first and second eyepiece lenses having fourth and fifth focal lengths, respectively
1508a
1508b
providing, in a first viewing mode, a first image viewable through the common eyepiece lens which comprises, in different parts thereof, respective portions of respective fields of view, FOV, through the first objective lens and through the second objective lens with different magnifications
providing, in a first viewing mode, a combined image viewable through the first and second eyepiece lenses simultaneously which comprises, in different parts thereof, respective portions of respective fields of view, FOV, through the first objective lens and through the second objective lens with different magnifications

Figure 15

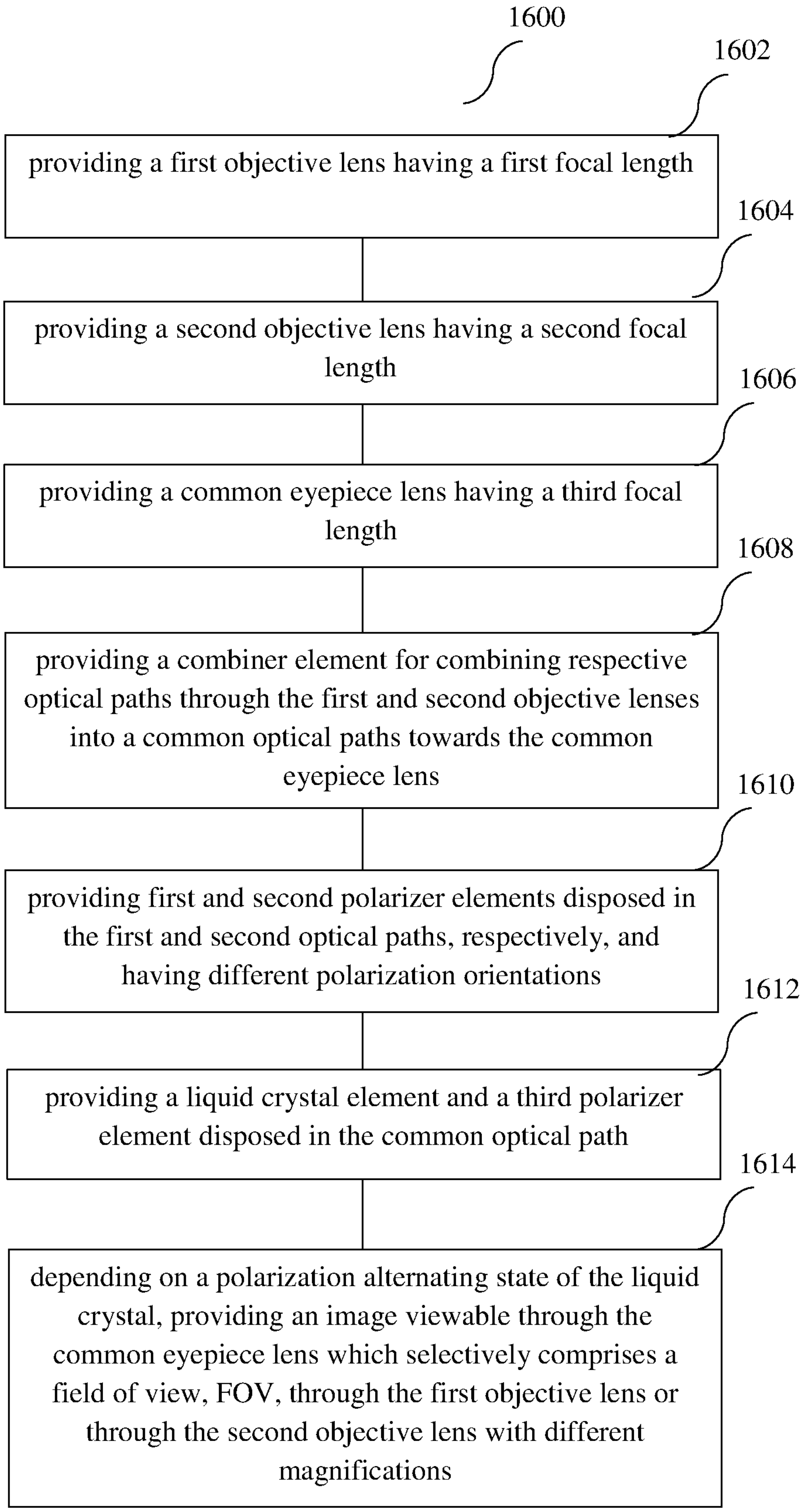

1600
1602
providing a first objective lens having a first focal length
1604
providing a second objective lens having a second focal length
1606
providing a common eyepiece lens having a third focal length
1608
providing a combiner element for combining respective optical paths through the first and second objective lenses into a common optical paths towards the common eyepiece lens
1610
providing first and second polarizer elements disposed in the first and second optical paths, respectively, and having different polarization orientations
1612
providing a liquid crystal element and a third polarizer element disposed in the common optical path
1614
depending on a polarization alternating state of the liquid crystal, providing an image viewable through the common eyepiece lens which selectively comprises a field of view, FOV, through the first objective lens or through the second objective lens with different magnifications

Figure 16

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG2021/050384

A. CLASSIFICATION OF SUBJECT MATTER

See Supplemental Box

According to International Patent Classification (IPC)

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G02B, G03B, G02F, H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

FAMPAT: telescope, sight, viewer, binoculars, monocular, spotter scope, periscope, viewfinder, rangefinder, magnification, zoom, field of view, FOV, different, combine, split, partial, dual, multiple, objective, eyepiece, ocular, polarization, liquid crystal, 观察镜, 望远镜, 瞄准镜, 潜望镜, 取景器, 测距仪, 放大, 缩放, 视野, 组合, 部分, 不同, 物镜, 目镜, 偏光, 偏振, 液晶 and related terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 2011/0128620 A1 (DENIS D. J.) 2 June 2011 Para. [0010]-[0016], Fig. 1-2	1-5, 11-13, 15-19, 21-23 6-10, 14, 20, 24
X	US 2016/0138889 A1 (BLAGOV P. A. ET AL.) 19 May 2016 Para. [0020]-[0026], Fig. 1, 6	1-5, 11-13, 15-19, 21-23
X	US 2632357 A (MIHALYI J.) 24 March 1953 Col. 3, ln. 36-39, col. 3, ln. 56-col. 4, ln. 13, Fig. 4-5	1-5, 11-13, 15-19, 21-23
X	US 2153198 A (MIHALYI J.) 4 April 1939 Pg. 1, right col. ln. 16-pg. 2, left col. ln. 26, Fig. 1-6	1-5, 11-13, 15-19, 21-23

☒ Further documents are listed in the continuation of Box C.　　☒ See patent family annex.

*Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30/09/2021 *(day/month/year)*	*30/09/2021* *(day/month/year)*

Name and mailing address of the ISA/SG

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG2021/050384

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2009/0052023 A1 (WINKER B.K. ET AL.) 26 February 2009 Whole document	
A	CN 206505222 U (CHENG K. ET AL.) 19 September 2017 Whole document of the original non-English language document (a machine translation is enclosed **only** for your reference)	

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please refer to Supplemental Box (Continuation of Box No. III).

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Supplemental Box
(Continuation of Box No. III)

This International Searching Authority found multiple inventions in this international application, as follows:

Group I: claims 1-13 and 15-23 are directed to a viewing apparatus comprising: a first objective lens having a first focal length; a second objective lens having a second focal length; and a common eyepiece lens having a third focal length or first and second eyepiece lenses having fourth and fifth focal lengths, respectively; wherein the viewing apparatus is configured, in a first viewing mode, that such: an image viewable through the common eyepiece lens comprises, in different parts thereof, respective portions of respective fields of view, FOV, through the first objective lens and through the second objective lens with different magnifications, or a combined image viewable through the first and second eyepiece lenses simultaneously comprises, in different parts thereof, respective portions of respective fields of view, FOV, through the first objective lens and through the second objective lens with different magnifications.

Group II: claims 14 and 24 are directed to a viewing apparatus comprising: a first objective lens having a first focal length; a second objective lens having a second focal length; a common eyepiece lens having a third focal length; a combiner element for combining respective optical paths through the first and second objective lenses into a common optical paths towards the common eyepiece lens; first and second polarizer elements disposed in the first and second optical paths, respectively, and having different polarization orientations; and a liquid crystal element and a third polarizer element disposed in the common optical path; wherein the viewing apparatus is configured that such: depending on a polarization alternating state of the liquid crystal, an image viewable through the common eyepiece lens selectively comprises a field of view, FOV, through the first objective lens or through the second objective lens with different magnifications.

Please refer to **Box No. IV** of Written Opinion of The International Searching Authority (Form PCT/ISA/237) for detailed explanation.

Supplemental Box
(Classification of Subject Matter)

Int. Cl.

G02B 23/04 (2006.01)

G02B 15/04 (2006.01)

G02B 27/14 (2006.01)

G02B 27/28 (2006.01)

G03B 13/00 (2021.01)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/SG2021/050384

Note: This Annex lists known patent family members relating to the patent documents cited in this International Search Report. This Authority is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2011/0128620 A1	02/06/2011	NONE	
US 2016/0138889 A1	19/05/2016	RU 2528121 C1 HK 1222457 A1 CN 105408797 A WO 2014/196897 A1 EP 3006985 A1 CA 2914627 A1	10/09/2014 30/06/2017 16/03/2016 11/12/2014 13/04/2016 11/12/2014
US 2632357 A	24/03/1953	NONE	
US 2153198 A	04/04/1939	NONE	
US 2009/0052023 A1	26/02/2009	NONE	
CN 206505222 U	19/09/2017	NONE	